OBSERVATIONS ON "*LAB - LAB*" CONSTITUENTS IN AND AROUND SOME CULTURE SYSTEMS AT KOCHI, KERALA STATE

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C E R T I F I C A T E

This is to certify that this Dissertation is a bonafide record of work carried out by Kum. Rema Bai, C.D. under my supervision and that no part thereof has been presented before for any other degree.

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CONTENTS

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P R E F A C E

Aquaculture is recognised as one among the frontier areas for augmenting fish and shellfish production to meet the demands of animal protein for the growing population and to mitigate the growing protein malnutrition, to some extent.

Recent studies have shown that substantial increase in production of culture fisheries could be achieved through judicious usage of operational inputs, including feed, fertilizers etc. Besides, studies in India and elsewhere have shown that survival, growth, nutrition and spawning of fish and shellfishes are significantly affected by the quality and quantity of the food availabile or supplied. Thus nutrition plays a vital role in aquaculture.

Countries bordering the Indian Ocean have a long history of experience in the cultivation of aquatic organisms and thus form important centres of aquaculture in the world. In India also such culture practices from time immemorial, on a traditional basis, have been established in many maritime States and have undergone development with regard to inland sector; but not so much in the marine and brackishwater sectors.

Coastal aquaculture in India at present has been largely at subsistence level, as it was in distant past, although potentials for its development are great. Experiments at various research centres have demonstrated the possibilities of successful salt water fish farming. India is endowed with large water resources suitable for fin fish culture and there are many species amenable for culture, such as the Milkfish Chanos chanos, Grey mullets Mugil spp., Liza spp., Seabass Lates calcarifer, etc. (James, 1985).

The Milk fish Chanos chanos (Forsskål) is one of the most important pond-raised finfish in terms of production, quality and demand. It is an algal feeder and shows better growth rate in culture systems, feeding on the benthic complex (Periphyton or Biological complex) of algae popularly called "Lab-Lab". It can be produced at a relatively low cost because of this and also its production can be managed with reliable profits in saline lands which are unsuitable for agriculture or animal husbandry (Rabanal and Shang, 1976). In India Milk fish culture was initiated by the State Fisheries Department of the then Presidency of Madras. From the available information on its culture (James 1985), it is evident that it has received attention mostly in Tamil Nadu State.

The technology for the propogation and sustained growth of "Lab-Lab" in the culture ponds in South-East Asian countries has advanced considerably for providing adequate supply of food to Chanos and other stocked animals, throughout the farming season; as well as in ensuring the culture operations on a viable basis. But, in India a concerted effort to develop a technology for the propogation and growth of "Lab-Lab" in culture ponds has not been made so far. A few experiments carried out by Central Marine Fisheries Research Institute at Mandapam during 1981 has shown that in India also there is a distinct possibility for enhancing and maintaining the growth of "Lab-Lab" in culture ponds as the food for Milk fish, so that culture of Chanos can be achieved successfully.

In the coastal and backwater areas of Kochi, an unorganised and unmanaged system of harvesting Chanos, Mullets etc, has been in vogue along with other organisms such as prawns. Since these fishes have to depend upon "Lab-Lab" and other algal food available in the natural state there, it is thought desirable to make a limited study of the "Lab-Lab" constituents that are present in a few water bodies, in and around some ponds which are mostly used for prawn culture. Such a study would give an insight of the organisms present as well as the interrelationship between them and the environmental parameters as well as the nutrients available.

This dissertation is mainly centred around the aspect of "Lab-Lab" constituents in relation to the environmental characteristics of different culture systems at Kochi during the pre-monsoon, monsoon and post-monsoon seasons of 1991.

The "Lab-Lab" which forms the natural food in the culture system are of considerable importance in the larval recruitment of some estuarine and coastal water fishes. It also serves as a primary food resource in the earlier stages of the life cycle of marine, estuarine and backwater organisms. And, the environmental factors play a vital role in the production and ecology of primary and secondary producers of the culture systems.

The main objectives of the present study are to obtain adequate information on the concentration of different "Lab-Lab" constituents, their distribution, relative abundance and quantitative assessment and the probable influence of monsoon, related hydrographic and sedimentological parameters. This study was planned since no work of such a nature is available in literature from the culture systems at Kochi.

The significance of the study of "Lab-Lab" constituents and their productivity, resume relevant literature and scope of the study are given under the title "INTRODUCTION". The description of the study area, station positions and treatments of data are included in "MATERIALS AND METHODS". The "RESULTS AND DISCUSSION" of the dissertation embody sections relating to:

Environment,
Hydrological parameters,
Sedimentological parameters,
Major Lab-Lab groups,
Total production of Lab-Lab,
Relative abundance and
Quantitative assessment of productivity potential and influence of hydrography and sedimentological parameters on the Lab-Lab constituents.

The salient features and findings of the present investigations are given in "SUMMARY" followed by the "REFERENCES" which include the relevant literature cited in this dissertation.

I wish to express my deep sense of gratitude to my Supervising Teacher Dr.P.Bensam, Principal Scientist and Head, Demersal Fisheries Division, CMFRI, Cochin for his constant advice, inspiring guidance throughout this work and critically going through the typescript, offering valuable suggestions and improvement. I express my sincere thanks to

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I T R O D U C T I O N

Aquaculture is the farming of useful aquatic animals and plants in fresh, brackish and marine environment under conditions of husbandry, management, nutrition and multiplication or breeding. In the world as at present, the day by day increase in human population has drawn more attention to the finite nature of aquatic resources as a source of protein. The trend of production from it, including the sea has reached a stage of stagnation. Thus, it is inevitable to go in for culture along with capture, in order to boost the protein supply for the ever increasing population.

In South-East Asian countries, the successful culture of Milkfish *Chanos chanos* depends on the growth and supply of "Lab-Lab" which is its food in the culture ponds. The Milkfish has good scope for culture along the Indian coast and the supply of its seed from nature is not a problem. In culture ponds it feeds at the bottom on the benthic algae present there. This feeding habit has been utilized for its successful commercial culture in Indonesia, Philippines and Taiwan (Shuster,1952; Pillai,1962 and Bardach *et al*.,1972).

The favourite food item of Milkfish is the benthic plant and animal complex called "Lab-Lab". This is composed of several microscopic organisms dominated chiefly by the blue-green algae *Oscillatoria*, *Phormidium*, *Lyngbya*, *Spirulina*, *Anabaena*, *Microcoleus*, *Chroococcus* & *Gomphosphaeria* (Schuster, 1952; Chacko & Mahadevan, 1956; Pillai, 1962; Bardach *et al*., 1972), the diatoms *Navicula*, *Pleurosigma*, *Amphora*, *Nitzschia*, *Gyrosigma*, *Nostogloia*, *Stauroneis*, etc. as well as other organisms like protozoa, bacteria, the zooplanktons represented by Copepods, Amphipods, Ostracods, Nematode worms, polychaete worms Molluscs, Cladocerans, Isopods, Tanaids etc. These elements of the biological plant and animal complex are suitable natural food for the cultivation of prawns and mullets also. From a review of literature it is evident that the sustained growth and maintenance of "Lab-Lab" in the culture ponds is the key factor for high production of the Milkfish.

The production of herbivorous fishes and their food organisms depend on soil fertility and the supply of nutrients from tidal water. Hickling (1969) emphasizes the importance of bottom soil in maintaining the fertility of the culture system since benthic algae which forms the main food organisms in ponds, grow on the pond soil base. Thus, the productivity of the pond is directly related to the nutrient status of the bottom mud (**Pillai, 1962**). The importance of the nature and properties of brackishwater fish pond soils on productivity of the pond has also been described by workers like Tang and

Chen (1967), Djajadiredja and Poernomo (1972) and others. Quite a good deal of work was done in the first half of the present century in the Philippines for utilizing fertilizers to increase pond productivity, especially the amount of natural food for fish. Planting of filamentous algal cuttings in ponds has been done to enhance the growth of Milkfish as its natural food. Also the commercial inorganic fertilizers (N-P -K of 14-14-14- or 12-12-12) were tried in the experiments (BFAR, 1976).

Additional research from newly established research centres in the seventies i.e., Brackishwater Aquaculture Centre (Under the university of the Philippines in the Visayas), the Freshwater Aquaculture Centre (under the central Luzon State University, Munoz, Nueva Ecija) and further aquaculture development Centre in Tigbauan Iloilo have added to the development of aquaculture in Philippines (Ballesteros,O.Q. and Mendoza, 1976). Much more research information on fertilization of ponds with organic and inorganic fertilizers are also generated. In experiments using rice bran at a rate of 4-6 tons/ha in Milkfish ponds in the Philippines, Ronquillo and Jesus (1958) observed a striking increase in the thickness of "Lab-Lab" upto 2 cm. Coastal aquaculture operations in the Philippines is mostly devoted to the farming of Milkfish on the above lines.

In the Philippines, the method of rearing of Milkfish in brackishwater ponds is still at the basic level of management and this has given rise to three types of culture methods which are based on the natural food grown in the ponds. These methods are called "Lumut" "Lab-Lab" and "Plankton" methods. Each method is having a different type of pond preparation (PACARRD, 1976).

In "Lumut" method, filamentous green algae are primarily grown in the pond. These are either planted on the pond bottom at an interval of 1 to 2 meters or broadcast from the dike or a boat . The water depth is maintained at a definite level, for allowing sufficient sunlight for their growth.

In "Lab-Lab" method, first the ponds are prepared by drying their bottom. For fertilization, chicken manure is applied at a rate of 1-2 tons/ha. Water level is raised slowly in the pond until it has reached 25 cm. Inorganic fertilizers such as Urea, Phosphates of the NPK combinations, Superphosphates, Triplephosphates etc are broadcast in the pond to maintain a good growth of "Lab-Lab".

In the "Plankton method", the natural food consists of plankton and it is found suspended in the pond water. In this method the ponds are first dried and filled with water, maintaining 75-100 cm depth. Fertilization with inorganic fertilizers are done according to the need.

Schuster (1952), Pillai (1962), Prowse (1966), Lin (1968), Djajadiredja & Poernomo (1972), Tang (1972), Chen (1972) and many others have drawn attention that for successful growth and maintenance of "Lab-Lab" in culture ponds in Indonesia, Philippines and Taiwan, an increase in the fertility of the pond is an essential prerequisite. Traditionally this has been accomplished by adding nutrients in the form of organic manures. Some common manures used are: Cow dung, horse dung, pig manure, chicken manure, tobacco waste, leaves and twigs of mangrove plants (*Avicennia*, *Rhizophora*). *Thephrosia*, *Pithecolobium*, rice straw, rice bran, copra slime, oilcakes of peanut, soyabean, coconut etc. These contain nutrients like nitrates, phosphates, and minerals and these accelerate the growth of blue-green algae and the accompanying fauna.

Ronquillo and Jesus 1958 have observed in the Philippines that there is a striking increase in the thickness of "Lab-Lab" in relation to the quantity of rice bran used to manure the ponds. In the sixties, fish culturists of Taiwan and Philippines have resorted to scientific use of fertilizers including inorganic nitrogeneous ones like Urea, Phosphate, Superphosphate, Triplesuperphosphate, NPK groups of fertilizers etc. Djajadiredja and Natawiria (1965) have observed a positive effect of urea in stimulating the growth of the algae. It is said that for the growth of blue-green algae, the ammonium carrying fertilizers like urea is better because of its high proportion of nitrogen and carbondioxide which is important in photosynthesis.

According to Bardach et.al., (1972) Chanos does not require extraneous feeding and the success of its culture is dependent upon "Lab-Lab" which can be maintained through proper fertilization of the pond soil and water chemistry. Tang and Chen (1967), Djajadiredja and Poernomo (1972) and others have drawn attention to the type and texture of the soil required at the pond bottom for successful growth of "Lab-Lab". They also emphasized the importance of bottom mud of the pond as the chemical laboratory in the culture ecosystem. According to them the best soil is "silty loam". It should be either 64,32 and 4 or 82, 16 and 2% silt, sand and clay respectively by composition. They also observed that draining the pond and tilling its soil is essential to make it colloidal which stimulate the growth of "Lab-Lab". According to Tang and Chen (1967), silty loan and loamy soils are most favourable for growing algal pastures. Frey (1947) & Schuster (1949) have observed that "Lab-Lab" production is greater when the bottom mud is peaty clay in nature than in other kinds of soils.

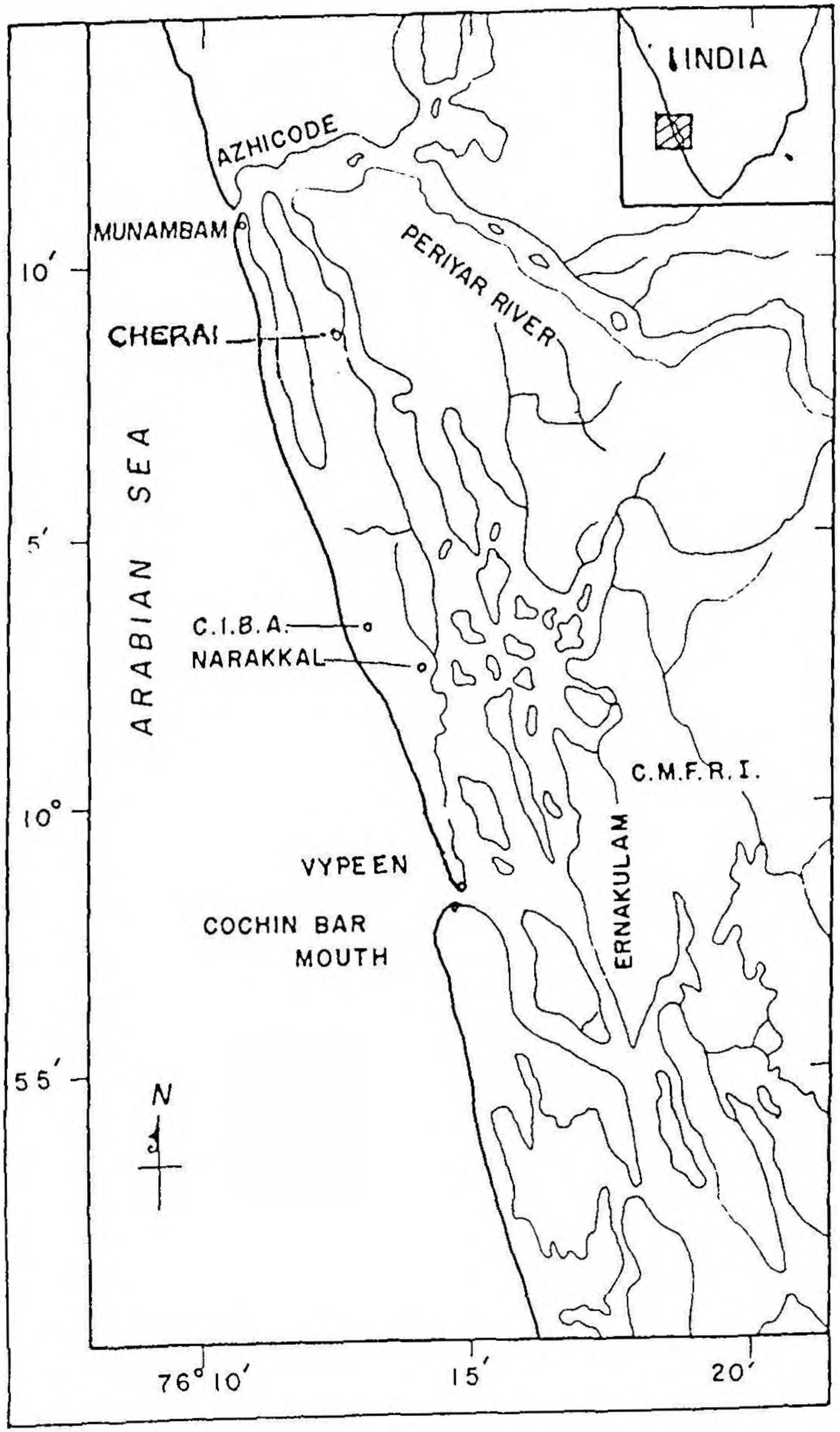
The organic matter content of the soil is very important for the growth of benthic blue-green algae. Since nitrogen is essential to stimulate algal growth and organic matter is a good source of slow but constant supply of it through bacterial and fungal decompositions, application of organic manure is necessary. A linear relationship between organic matter content of the bottom soil and Milkfish production has been demonstrated by Tang and Chen (1967) in Taiwan. Several factors like fertilization period, rainfall, depth of water, salinity etc are known to influence the growth of this natural food. Water depth plays an important role for the production of "Lab-Lab" Sulit et. al., (1958) and also according to them a depth between 10 and 16 cm is favourable for growing Cyanophyceae, whereas Schuster (1949) reported between 1 and 50 cm to be the optimum depth. Water salinity is also important along with other parameters and it should be between the range of 15 and 30 ppt (Shuster, 1949).

In India, experiments on culture of *Chanos* was started in the seventies of the last century (Thomas, 1870). Although a good growth of "Lab-Lab" is essential for the success of Milkfish farming, a persual of literature on *Chanos* culture experiments in ponds and pens carried out in India so far (Chacko and Mahadevan, 1956; Tampi, 1960; Bensam and Marichamy 1982; Mohan 1983 a,b, & c 1990; Mahadevan 1985; Gandhi and Mohanraj, 1986; and Marichamy, 1987). shows that the aspect of enhancing and sustaining the production of "Lab-Lab" has not been given an adequate thrust which it deserves. Hence for the successful commercial farming of Milkfish, in India also, it is essential to develop the technology for sustained growth and maintenance of "Lab-Lab" as the food of *Chanos* similar to the conditions developed in the South-East Asian countries. This is very important as there is considerable scope for commercial culture of *Chanos* in India (James, 1985).

In India, Chacko and Mahadevan (1956) have reported the presence of blue-green algal complex in the swamps in which an experimental culture of Chanos was undertaken. Tampi (1960) has made use of certain compost manures for the production of plankton in the pond as well as the growth of a benthic layer of greenish scum consiting of blue-green algae, diatoms, etc. Recent work of Bensam (in press) at Mandapam has shown that, by manuring culture ponds, it is certainly possible to enhance the production of "Lab-Lab" constituents like Phormidium, to at least 66 times more than that of natural unmanured conditions. The "Lab-Lab" formation has been found to be present in small quantities in coastal lagoons, swamps, ditches and similar water bodies in India quite now and then, thus indicating that if only suitable efforts are taken, there is every possibility for enhancing its production in culture ponds also.

A review of literature reveals that a great deal of contribution exists on the benthic flora and fauna in coastal zone ecosystems, such as brackishwater lakes, estuaries, backwaters and inshore waters. However, there has not been any concreted effort to investigate the benthic flora and fauna of coastal culture systems, such as ponds, lagoons, and bays. In view of the importance of "Lab-Lab" in the food chain of the fishes and prawns suitable for coastal aquaculture in India, it is very much essential that some knowledge is generated on the "Lab-Lab" constituents in localities which support one or the other kind of culture operations for these organisms. An attempt is therefore made to study the abundance and distribution of the benthic complex in certain brackishwater prawn/fish culture fields at Kochi from April to October 1991 along with observation on environmental parameters as a part of the programme, for the Degree of Master of Science in Mariculture.

Fig. 1   Map showing study area and station positions.



MATERIALS AND METHODS

1. Selection of Stations:

Four representative culture systems are selected for the present study and the samples were collected fortnightly from each and every station. A map of the study area along with the sites selected is given in Fig 1

Station I

The 'Pokkali' fields at Cherai is selected as the first station (Plate I). This is a seasonal prawn culture area where prawn and paddy cultivation are carried out during different times of the year. Prawns are usually cultured from middle of November to middle of April and during this period the brackish nature of the water is suitable for it. Paddy is cultivated from June to September. The "Pokkali" is a saline resistant strain of paddy. The intervening periods are used for the preparation of the field.

During the present study, the preparation of the field for paddy cultivation and seeding of the field were observed during the first half of the work and paddy cultivation was carried out during the second half.

Station II.

The Second station selected is a coconut palm canal at Narakkal (Plate II). The canals in the coconut groves are

Plate I. Pokkali fields (the seasonal paddy-cum-prawn culture fields) at Cherai, Station I.

Plate II. Coconut groves at Narakkal, Station No. II.

primarily excavated between rows of coconut trees in order to irrigate the grove, but the water body is profitably utilized as a culture system for prawns and fishes. The canals in the coconut grove are a typical brackishwater environment and cover an area of about 1.5 hectares. The system is connected to Cochin backwaters through a network of canals. The coconut grove canals have a water depth of 50 to 75cm.

Station III.

The third station selected is an experimental perennial culture pond, belonging to the Central Institute of Brackish Water Aquaculture (CIBA), at Narakkal (Plate III). The pond is separated from the sea by about 250 m of land strip and is connected by a canal to Cochin backwaters. Water from an adjacent canal is flown into the pond through a wooden sluice gate. The pond is about 0.6 ha area and is stocked with *Penaeus indicus*. This station is different from the other because of the culture practice undertaken in it along with management procedures including pond preparation, fertilization, feeding, water exchange etc. The average depth of the pond is about 85 cm.

Station IV.

The fourth site is the CIBA Supply Canal near to Station No. III.(Plate IV). This is connected to the experimental pond through a wooden sluice gate. The average depth of the canal is about 95 cm.

Plate III. Experimental pond (Perennial) of CIBA, Narakkal, Station III.

Plate IV. CIBA Supply canal at Narakkal, Station IV.

2. <u>Selection of parameters</u>:

Data on the following parameters were collected from all the four stations.

2.1. <u>WATER</u>:

2.1.1. Temperature.

2.1.2. Depth at the stations and Turbidity of water.

2.1.3. Dissolved oxygen

2.1.4. Salinity

2.1.5. pH

2.1.6. Free Carbon dioxide

2.1.7 Nutrients:

2.1.7.1 Nitrate

2.1.7.2 Phosphate.

2.2. <u>SOIL</u>:

2.2.1. Total Nitrogen

2.2.2. Available Phosphorus.

2.2.3. Organic Carbon.

2.2.4. Organic matter.

2.3. "<u>Lab-Lab</u>" constituents both algal and animal ones.

2.3.1. <u>Algal Complex</u>:-

2.3.1.1 Blue green algae

i) <u>Oscillatoria</u>

ii) <u>Phormidium</u>

iii) Lyngbya

iv) Spirulina

2.3.1.2 Diatoms:-

i) Pleurosigma

ii) Navicula

iii) Amphora

iv) Nitzschia

v) Coscinodiscus

2.3.2. Microfauna:-

i) Copepods

ii) Amphipods

iii) Polychaete worms

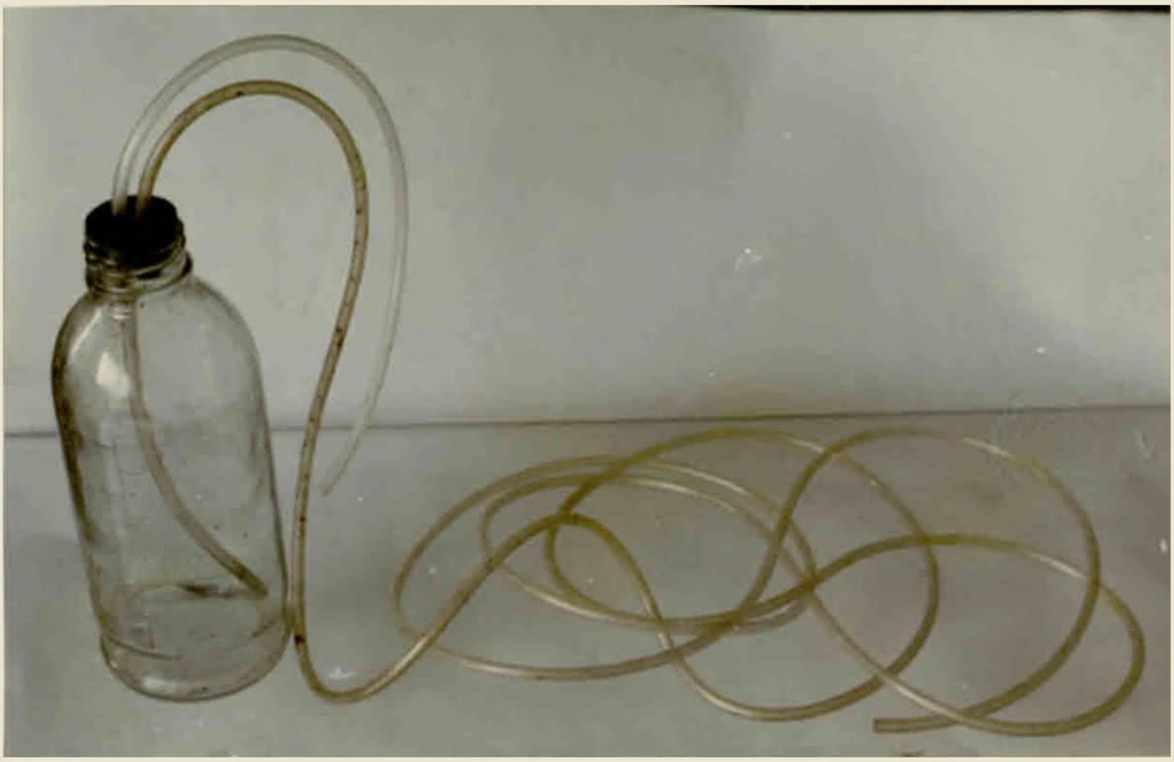
iv) Lamellibranch spat

3. Collection Methods:

Surface water samples were collected in narrow mouthed screw capped airtight polyethylene bottles of 250 ml capacity for estimation of salinity, pH, micronutrients and carbondioxide; and brought to the laboratory in an ice box. The bottom water samples were collected by a bottom water sampler, (Plate V.).

For the estimation of dissolved oxygen the surface and bottom water samples were collected in 125 ml glass stoppered bottles without entangling air bubbles within and the samples

Plate V. Bottom water sampler



were fixed with 1 ml each of winkler A and B solutions respectively at the collection site. The bottles were shaken gently till precepiation has formed and transported to the laboratory for analysis.

Soil samples were collected using a Van-Veen Grab of 0.5 m^2 and were kept in polythylene bags. In the laboratory, each sample was dried at 70°C in an oven, powdered and sieved through a 2 mm mesh for analysis.

"Lab-Lab":- The "Lab-Lab" is scrapped offthe bottom with a "Lab-Lab" samplerconsisting of a basal plate of 15x15 cm. of Galvanised Iron (GI) sheet and from this an area of 10x10 cm is scrapped off with a scalpel and the samples were made up into a known volume and preserved in 5% formalin.

Temperature: The temperature of the surface and bottom water were recorded at the collection site by a mercury thermometer ranging between 0-50°C.

Turbidity and depth:- Transparency is inversely proportional to the turbidity of water which in turn is directly proporational to the amount of suspended organic and inorganic matter. When a Secchidisc is gradually lowered in the water it remains visible in the euphotic zone only where light is about 15% of the radiation at the surface.

Plate VI. "Lab -Lab" growth on the pond bottom at Narakkal coconut groves.

A Secchidisc is lowered in the water tied with rope and the depth at which it disappears was noted. After a little more lowering, it was raised upward and the depth at which it reappears also was noted. The average value of these two readings was calculated in cm. The euphotic limit is calculated as follows.

Euphotic limit = 2.5 x Sdd.

The depth of the pond itself was measured by lowering the Secchidisc up to the bottom and the value was obtained in cm by measuring the length of the rope in water by a wooden scale.

4. Laboratory analyses of samples:

WATER:

Dissolved oxygen: Dissolved oxygen content of the water samples was estimated by the "Modified Winkler Method", as given by Strickland and Parsons (1968).

Salinity: Salinity of surface and bottom water samples were estimated by "Mohr-Kundson method", also as given by Strickland and Parsons (1968).

pH: The pH of the water samples were measured in the laboratory, using a digital pH meter, immediately after the collection. The pH meter was standardised by using the buffer solutions of acidic and alkaline pH solution. The buffer solutions of pH 9.2 was prepared by dissolving a pH tablet having pH 9.2 in 100 ml distilled water and the acidic buffer solution was prepared by dissolving a 4.2 pH tablet in 100 ml distilled water.

Carbondioxide: The free Carbondioxide in the water sample was estimated by the method cited by Adoni (1985). 50 ml of the sample was taken in a flask and 2 drops of phenolphthalein indicator was added to it. If the solution remained colurless, it was treated with the standard alkali titrant (0.227N. NaOH) to a slight pink end point. The free carbondioxide in milligrams per litre is calculated by the formula:

$$\text{Free } CO_2 \text{ in mg/l} = \frac{\text{ml. of the titrant}}{\text{ml. of sample}} \times 1000$$

Nitrate: The nitrate is estimated by "Morris and Riley method" as given by Strickland and Parsons (1968).

Reactive Phosphorus: The analytical procedure of Strickland and Parsons (1968) was followed for the estimation of reactive phosphorus.

SOIL

Available Phosphorus: The available phosphorus was determined clorimetrically using a Spectrophotometer. 5 gm soil was taken and added 1 gm of activated charcoal and 100 ml of olsen extracting reagent(0.5 M. Sodium bicarbonate 12 gm/l. and adjust the pH to 8.5) and this is kept in the mechanical shaker for 30 minutes, and it is filtered, and then the filterate is collected. This filterate is used to determine the phosphate colorimetrically against 660 μ. filter.

5 ml of the soil extract was pipetted out into a conical flask and to this 5 ml of D & B reagent (15 gm ammonium molybdate dissolved in 300 ml.of 10 N Hcl and make upto 1 litre) was added. The sample is then diluted to 22 ml. Added 1 ml of diluted stannous chloride (Dissolve 10 gm of stannous chloride in 25 ml concentrated Hcl by warming and store in amber coloured bottle and before use dilute 1 ml. of the above to 66 ml by adding distilled water) and made up to 25 ml. Then the colour density was measured within 5 minutes.

For Phosphate standard 0.4390 gm potassium dihydrogen phosphate in 100 ml distilled water, 25 ml of 7 N sulphuric acid is added and then made up to 1000 ml. From this 100 ppm solution, different substandard were prepared (2, 5, 10, 20, 30 50 and 70 ppm).

The same procedure was followed for the colour development for standard also repeated the same procedure for all standards and the calibration curve with OD on y axis and concentration on the x axis is drawn.

From the measured OD of the sample, its concentration was determined from the calibration curves and the available phosphorus in μg/gm is calculated by the following formula.

Available Phosphorus = PO_4 concentration x $\frac{50}{5}$ X $\frac{50}{2.5}$

(Olsen, 1954).

Total Nitrogen: It was calculated directly by multiplying the organic matter value by a factor 0.05 cited by Jackson(1973).

Organic Carbon: The organic carbon in the soil was determined by "Wet oxidation method" as cited by Walkley and Black (1935).

Organic Matter: It was calculated directly by multiplying the organic carbon value by a factor of 1.724 as given by Jackson (1973).

Analysis of soil grain size

Dried soil sample passing through a 2 mm sieve was analysed for grain size composition by the "Pipette" method cited by Dewis and Freitas (1970).

5. "Lab-Lab": The samples from an area of 10 x 10 cm^2 were made into a known volume with water and the number of algae and other constituents of "Lab-Lab" from an aliquote were counted under a microscope. The length of the algal filaments were recorded and mean length of each sample was calculated. The total length of the filements per 100 cm^2 is computed by multiplying the estimated number of filaments by their mean length in each case.

For the estimation of aquatic fauna like copepodes, amphipods, cladocerans, polychaete worms etc, the organisms were separated from an area of $10x10cm^2$ by sieving it through a tub of water, to avoid any damage to the animals while sieving as recommended by Mc Intrye and Holnes (1971). After seiving, the organisms were preserved in 5% formalin with rose bengal to provide colour contrast between the animals and sediment fraction, as followed by Williams and Williams (1974). The rose bengal was added at a rate of 1 gm/l of formalin. The number of organisms was counted and the total number of organisms is expressed as per 100 cm^2 area.

5. <u>Statistical Analysis</u>:

The respective mean values of surface and bottom water parameters were computed and tabulated. The values of each parameter for twelve collections for each station were fed to the computer for one way analysis and the test of significance between stations was made. These analyses were made for water, sediment and individual "Lab-Lab" constituents.

Inorder to find the influence of environmental parameters on the production of "Lab-Lab", linear regression analysis were also done, taking X as the environmental parameter and Y as the biological parameter.

6. Graphical Analysis:

From the anova analysis, the parameters at respective stations, showing the significant differences were sorted out for plotting the graphs to make correlation study.

After getting result from linear regression analysis, the parameters showing significant influence on the total production of "Lab-Lab" were taken for graphical respresentation.

R E S U L T S

OBSERVATIONS AND RESULTS

Water Depth:

In the four stations where the investigations were carried out, the depth of water has varied from: 18 to 45 cm, at Cherai Pokkali fields (station I), 52 to 72 cm at Narakkal coconut groves (station II), 47 to 57 cm at CIBA experimental pond, (Station III) and 48 to 85 cm at CIBA Supply canal, (Station IV).

The water was clear and not turbid at all stations throughout the present investigations. Light penetration did not show much variation from station to station and the Secchi disc readings have varied from 40 to 64 cm among the stations, attaining a mean value of 52 cm in the study area during April to October 1991. Accordingly, the mean euphotic limits determined for the four stations are: 66, 133, 125 and 127cm respectively.

Rainfall data:

The monthly rainfall data recorded from April 1991 to October 1991 were: 71, 80, 1492, 541, 433, 54 and 49 mm for the respective months, with the peak in June.

HYDROLOGICAL PARAMETERS:

Environmental parameters i.e., water temperature, pH, dissolved oxygen, salinity, free carbondioxide, nutrients (phosphate and nitrate) and sedimentological parameters like organic carbon, organic matter, available phosphorus and total nitrogen were determined during the Ist and IIIrd weeks of each month from April to October 1991. The details are as given below:

Water Temperature:

During the study in Cherai, Pokkali fields, the temperature values ranged between 26.5°C and 33.5°C. The values increased gradually from April and after reaching the peak of 33.5°C in May premonsoon season, and it declined to 26.5°C in the third week of June with the onset of the South-west monsoon. A secondary peak of 31.25°C was also recorded during the first week of October (Table : 1).

In Narakkal coconut groves, the temperature has reached the peak of 32.85°C in May and thereafter the values showed fluctuations bwetween 27.95°C and 32.75°C. With the onset of the monsoon during June, it has showed a decreasing trend recording the lowest value of 27.95°C in the first week of July (Table : 2).

In the CIBA experimental pond, the temperature has showed a peak of 34.63°C during the first week of May. Due to the onset of the monsoon, the lowest value of 29°C was recorded in the third week of June. A secondary peak of 33.25°C was also recorded during the first week of October (Table : 3).

In the CIBA Supply canal, the temperature has ranged between 34.5 and 28.0°C with the peak value of 34.5°C recorded during the third week of April and the lowest value in third week of June (Table : 4).

pH:

In Cherai pokkali fields the recorded range in hydrogen ion concentration value was between 5.64 and 8.08. Peak value of hydrogen ion was recorded in first week of July and the lowest in third week of May (Table : 1).

In Narakkal coconut groves, the pH value ranged between 5.73 and 8.17 with lowest value in first week of June and peak value in July first week (Table 2).

In the CIBA experimental pond, the pH has ranged between 5.87 and8.25 and the peak value (8.25) recorded in third week of July and the minimum (5.87) in the first week of June (Table.3).

In the CIBA supply canal the pH values were between 5.65 and 8.17. The peak was recorded in July first week and the lowest was recorded in the first week of June (Table.4).

Salinity:

In Cherai pokkali fields the salinity values ranged between 0.63 to 27.0 ppt. The peak value was recorded in the third week of April and subsequently the values have declined to 0.63 ppt in the third week of August, due to the influx of freshwater during the monsoon (Table 1).

In Narakkal coconut groves the salinity has gradually increased from 16.69 ppt in April to a peak value of 24.66 ppt in June first week and again it has declined to 1.8 ppt in June third week. The values have fluctuated between 2.6 and 8.96 ppt in the course of other months (Table 2).

In the CIBA experimental pond, the salinity has ranged between 26.47 and 2.65 ppt during the period of study and the peak value was in June first week. Gradually it has declined to 2.65 ppt with the onset of monsoon and showed the lowest value in September first week (Table.3).

In the CIBA supply canal, the higher salinity values of 23.3 ppt was recorded during June first week and the lowest of 2.07 ppt was during August third week (Table.4);

From anova analysis, it is seen that the temperature, pH and salinity between four stations do not show significant variations between the stations, during the period of the present study (Table 18).

Dissolved oxygen:

In Cherai pokkali fields, the dissolved oxygen values have ranged between 1.10 and 4.93 ml/l. These have gradually increased from April and reached a peak value of 4.93 ml/l in June first week (Table 1).

In Narakkal coconut groves, the values were found to be lower in April first week 1.56 ml/l and higher in June third week (6.74 ml/l) (Table 2).

In the CIBA experimental pond, the values ranged between 2.13 and 4.42 ml/l. The maximum value was in early May and the minimum was in the latter half of September (Table 3).

In the CIBA supply canal, the values showed an increasing trend from the middle of April to the latter half of May with a peak of 3.42 ml/l in early May. The lowest value of 1.41 ml/l was recorded in early September (Table 4).

Statistically it has been seen that the values between Cherai pokkali fields and Narakkal coconut groves, Cherai pokkali fields and CIBA experimental pond have varied significantly at 5% level (Table 18).

Free Carbondioxide:

In Cherai pokkali fields, the free carbondioxide values ranged between 4 and 13 mg/l. The highest CO_2 level was observed in the premonsoon period i.e, in the latter half of April (13 mg/l) and the lowest in June (4 mg/l). A secondary peak of 10 mg/l was recorded in early July and the lowest during early August and in early September (Table 1).

In Narakkal coconut groves the free carbondioxide values showed a gradual increasing trend from April and reached the maximum of 12 mg/l in early May and reached the lowest of 4 mg/l in early September (Table 2).

In the CIBA experimental pond, the values ranged between 4 and 17 mg/l. The peak value of 17 mg/l was in early May and the lowest value of 4 mg/l. in the latter half of September (Table 3).

In the CIBA supply canal, the highest free carbondioxide value of 12 mg/l was recorded during April and the lowest of 5 mg/l was recorded in early August (Table 4).

Statistically, the free CO_2 values did not show any significant variation between the four stations (Table 18).

<u>Nitrate</u>:

During the study, the nitrate value in Cherai Pokkali fields ranged between 0.13 to 2.19 μg at/l. The maximum value was recorded in early May and the minimum in July third week (Table 1).

In Narakkal coconut groves the nitrate value ranged between 0.12 and 2.79 μg at/l. The peak value of 2.79 μg at/l was in June third week and the lowest of 0.12 μg at/l in July third week (Table 2).

In the CIBA experimental pond the nitrate value showed an increasing trend from April to early half of July with a peak of 2.54 μg at/l in June first week. The lowest value of 0.07 μg at/l was recorded in July third week (Table 3).

In the CIBA Supply canal also the values showed an increasing trend and the maximum value of 2.25 μg at/l was recorded in May third week and the minimum value of 0.13 μg at/l in October first week (Table 4).

These values did not show any significant variation between stations as shown by statistical analysis (Table 18).

<u>Phosphate</u>:

The concentration of phosphate in Cherai pokkali fields ranged between 1.1 and 5.70 μg at/l.

Table 1. Distribution of hydrological parameters in Cherai pokkali fields (Station I) during April - October 1991.

Seasons	Months	Weeks	Temperature (°C)	pH	Salinity (ppt)	Dissolved-Oxygen. (ml/1.)	Free CO_2 (mg/1)	Nitrate (µg at/1)	Phosphate (µg at/1)
Pre-Monsoon	April	III	32.25	7.42	27	1.63	13	1.00	5.70
	May	I	33.50	6.97	26.13	2.51	11	2.19	2.83
		III	33.25	5.64	24.00	2.55	8	1.05	1.16
		I	29.5	5.94	21.5	4.93	4	1.81	1.25
	June	III	26.5	7.72	2.6	4.15	4	1.01	2.2
Mon-soon	July	I	28.88	8.08	2.31	3.25	10	0.29	7.13
		III	27.5	7.90	2.12	2.00	6	0.13	1.1
	August	I	28.75	7.89	1.35	1.4	7	0.62	2.6
		III	27.87	7.82	0.63	2.87	4	0.42	1.8
Post-Mon-soon	Sept-ember	I	30.4	7.46	1.41	1.01	4	0.22	1.78
		III	30.5	7.64	7.65	1.33	10	1.15	2.5
	October	I	31.25	7.95	8.2	1.47	6	1.25	2.2

Table 2. Distribution of hydrological parameters in Narakkal coconut groves (Station II) during April - October 1991.

Seasons	Months	Weeks	Temperature (°C)	pH	Salinity (ppt)	Dissolved Oxygen. (ml/1.)	Free-CO_2 (mg/1)	Nitrate (μg at./1)	Phosphate (μg at./1.)
Pre-Monsoon	April	III	32.38	7.09	19.69	1.56	10	0.25	5
	May	I	32.65	7.79	15.83	5.57	12	0.12	7.6
		III	32.5	7.66	19.55	3.62	9	1.89	4.6
Mon- soon	June	I	30.25	5.73	24.66	2.97	7	2.61	2.15
		III	27.95	7.96	1.8	6.74	5	2.79	2.88
	July	I	29.25	8.17	3.09	2.9	8	2.06	8.9
		III	29.4	8.12	3.39	2.22	7	0.12	14.75
	August	I	30.0	7.97	2.43	2.17	7	1.81	9.6
		III	29.5	8.14	2.5	4.69	6	1.27	6.05
Post-Monsoon	September	I	30.15	7.97	2.6	3.13	4	0.45	12.25
		III	27.75	7.85	7.73	2	7	0.15	6.75
	October	I	32.75	7.75	6.96	4.84	5	0.16	6.1

Table 3. Distribution of hydrological parameters in the CIBA experimental pond (Station III) during April - October 1991.

Seasons	Months	Weeks	Temperature (°C)	pH	Salinity (ppt)	Dissoved-Oxygen. (ml/1.)	Free-CO_2 (mg/1.)	Nitrate (µg.at.1)	Phosphate (µg.at./1)
Pre-Monsoon	April	III	33.5	7.29	20.05	2.54	9	0.28	6.25
	May	I	34.63	7.2	16.38	4.01	17	0.39	2.9
		III	31.77	7.14	21.15	3.98	9	2.6	2.6
Mon-soon	June	I	29.27	5.87	26.47	3.81	5	2.54	3.1
		III	29	8.07	3.79	2.99	5	0.8	11.7
	July	I	30	8.13	4.0	4.42	7	1.91	9.58
		III	30	8.25	5.18	2.23	6	0.07	12.4
	August	I	30.5	8.07	3.45	3.11	7	1.65	2.15
		III	30.25	8.01	3.08	4.24	7	0.69	7.25
Post-monsoon	September	I	32.25	8.06	2.65	3.92	6	0.65	8.33
		III	30.5	8.03	6.74	2.13	7	0.23	11.03
	October	I	33.25	7.88	7.97	4.37	7	0.19	4.13

Table 4. Distribution of hydrological parameters in the CIBA supplycacanal (Station IV) during April - October 1991.

Seasons	Months	Weeks	Temperature (°C)	pH	Salinity (ppt)	Dissolved-Oxygen. (ml/l)	Free - CO_2 (µg/l)	Nitrate (µg at/l)	Phosphate (µg at/l)
Pre-Monsoon	April	III	34.5	7.22	19.2	3.19	12.00	0.31	6.00
	May	I	34.0	7.06	16.65	3.92	8	1.04	1.82
Mon-soon	June	I	29.85	5.65	23.3	3.01	8	0.27	1.8
		III	28	7.92	3.4	2.59	8	2.27	3.25
	July	I	29.5	8.17	3.57	2.76	9	0.37	8.15
		III	29.88	8.07	5.55	2.1	6	1.1	12.08
	August	I	30	7.87	3.03	2.49	5	1.2	11.7
		III	29.63	8.01	2.07	1.63	9	0.86	6.23
Post-Monsoon	September	I	32.25	7.69	2.28	1.41	7	0.44	6.95
		III	30.25	7.89	7.65	2.44	7	0.16	6.75
	October	I	33.0	7.98	7.51	3.3	5	0.13	10.5

The minimum of 1.1 μg at/l was observed in August first week and the maximum of 5.70 μg at/l in April (Table 1).

In Narakkal coconut groves, the values showed a fluctuation between 2.88 and 14.75 μg at/l. The minimum was observed in June and the maximum in July third week (Table 2).

In the CIBA experimental pond the values ranged between 2.15 and 12.4 μg at/l with the maximum of 12.4 μg at/l in July third week. The minimum value of 2.15 μg at/l was in August (Table 3).

In the CIBA supply canal the values showed fluctuations from 1.8 to 12.08 μg at/l. The minimum was observed in June and the maximum in July (Table 4).

From the anova analysis it is seen that the values between Cherai pokkali field and Narakkal coconut groves (station I and II), Cherai pokkali field and CIBA experimental pond (Station II and III), and Cherai pokkali fields and CIBA supply canal (Station I and IV) have varied significantly at 5% level. (Table 18).

SEDIMENTOLOGICAL PARAMETERS:

Organic carbon:

The percentage organic carbon in the sediment at Cherai pokkali fields showed fluctuations from 1.08 in September to 3.68 in May (Table 5).

In Narakkal coconut groves it showed fluctuations between 2.73 and 0.75%. The maximum was in May and thereafter the values have declined gradually to the least in October (Table 6).

In the CIBA experimental pond the percentage of organic carbon varied between 0.9 and 1.68. The least value was noticed in June third week and the highest in September third week (Table 7).

In the CIBA Supply canal the percentage of it showed fluctuation between 0.9 and 1.68. The lowest value was in June third week and the highest in September third week. (Table 8).

Statistically the organic carbon content has not shown any significant variation between the four stations (Table 20).

<u>Organic matter:</u>

The percentage of organic matter in the pokkali fields of Cherai has varied between 1.86 in September and 5.99 in May (Table 5).

From the soil of Narakkal coconut groves, the organic content was estimated and found between 1.29 in October and 4.70 in May (Table 6).

In the CIBA experimental pond the organic matter content has varied between 1.13 and 5.51%. The minimum was in October and the maximum inAugust third week (Table 7).

The range of organic matter content in the CIBA Supply canal varied between 1.55 and 2.89%. The minimum was in June third week and the maximum in September third week (Table 8).

Statistically it is seen that the values between Cherai pokkali fields and the CIBA Supply canal have varied significantly at 5% level (Table 20).

Available phosphorus:

The available phosphorus in Cherai pokkali fields estimated has ranged between 38.08 and 134.4 μg/gm. The maximum was in September and the minimum was in June (Table 5).

In Narakkal Coconut groves, it ranged between 52.32 and 163.97 μg/gm. The lowest value was in May third week and the highest concentration was in August first week (Table 6).

In the CIBA experimental pond the values showed a fluctuation between 58.62 and 130.82 μg/gm. The minimum was in June and the maximum was in September (Table 7).

During the present study in the CIBA supply canal, the available phosphorus content showed fluctuations between

56 and 142.61 μg/gm. The maximum value was in September third week and the minimum in April third week (Table 8).

Statistically, the values between Narakkal coconut groves and the CIBA experimental pond have differed significantly at 5% level (Table 20).

Total nitrogen:

The percentage of total nitrogen has fluctuated between 0.09 and 0.29 in Cherai pokkali fields. The minimum was noticed in September and the maximum in May third week (Table 5).

The total nitrogen in Narakkal coconut groves has varied between 0.06 and 0.24%. The minimum was in October and maximum in May third week (Table 6).

In the CIBA experimental pond, it showed a fluctuation between 0.09 and 0.275%. The minimum value was noticed in June third week and September third week and the maximum was observed in August third week (Table 7).

The total nitrogen in the CIBA supply canal has varied between 0.07 and 0.135%. The minimum was observed in June third week and the maximum in August third week (Table 8).

Statistically the total nitrogen value has not shown any significant variation between the four stations (Table 20).

Table 5. Distribution of sedimentological parameters in Cherai pokkali fields (Station I) during April - October 1991.

Seasons	Months	Weeks	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (µg/gm)
Pre-Monsoon	April	III	2.76	4.75	0.24	73.9
	May	I	2.58	4.44	0.22	62.72
		III	3.48	5.99	0.29	52.92
Mon-soon	June	I	3.48	5.99	0.28	38.08
		III	1.68	2.89	0.14	65.408
	July	I	2.04	3.51	0.18	85.12
		III	1.68	2.89	0.14	125.44
	August	I	1.56	2.68	0.13	87.808
		III	1.20	2.06	0.10	96.32
Post-Monsoon	Septe-mber	I	1.08	1.86	0.09	125.44
		III	1.08	1.86	0.09	134.44
	October	I	1.56	2.68	0.13	120.44

Table 6. Distribution of sedimentalogical parameters in Narakkal coconut groves (Station II) during April - October 1991.

Seasons	Months	Weeks	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available-Phosphorus (µg/gm)
Pre-Monsoon.	April	III	1.38	2.37	0.12	100.8
	May	I	1.38	2.37	0.12	59.58
		III	2.73	4.70	0.24	52.32
Mon-soon.	June	I	2.43	4.18	0.21	138.88
		III	1.77	3.05	0.15	96.32
	July	I	1.65	2.84	0.14	93.36
		III	1.77	3.05	0.15	113.34
	August	I	1.2	2.06	0.10	163.97
		III	1.68	2.89	0.14	96.32
Post-Monsoon	September	I	1.11	1.91	0.10	107.52
		III	1.68	2.89	0.14	118.32
	October	I	0.75	1.29	0.06	100.8

Table 7. Distribution of sedimentological parameters in the CIBA experimental pond (Station III) during April-October 1991.

Seasons	Months	Weeks	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available-Phosphorus (µg/gm.)
Pre-Monsoon	April	III	1.38	2.37	0.118	98.56
	May	I	1.44	2.48	0.124	73.92
		III	2.16	3.72	0.186	63.82
Mon-soon	June	I	1.74	3.03	0.15	130.82
		III	1.02	1.75	0.09	64.96
	July	I	1.38	2.37	0.118	64.96
		III	1.35	2.32	0.116	71.23
	August	I	1.23	2.12	0.106	98.56
		III	3.2	5.51	0.275	96.32
Post-Monsoon	September	I	1.47	2.53	0.126	62.72
		III	1.08	1.86	0.09	58.62
	October	I	0.66	1.13	0.056	52.72

Table 8. Distribution of sedimentological parameters in the CIBA supply canal (Station IV) during April - October 1991.

Seasons	Months	Weeks	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (µg/gm)
Pre-Monsoon	April	III	1.08	1.86	0.09	56
	May	I	1.35	2.32	0.116	100.8
		III	1.47	2.53	0.126	98.5
Monsoon	June	I	1.11	1.91	0.09	71.23
		III	0.9	1.55	0.07	56.0
	July	I	1.29	2.22	0.111	93.36
		III	1.35	2.32	0.116	73.92
	August	I	1.53	2.63	0.135	68.54
		III	1.56	2.68	0.134	90.496
Post-Monsoon	September	I	0.92	1.55	0.077	138.68
		III	1.68	2.89	0.14	142.6
	October	I	1.41	2.43	0.121	132.61

Grain size analysis:

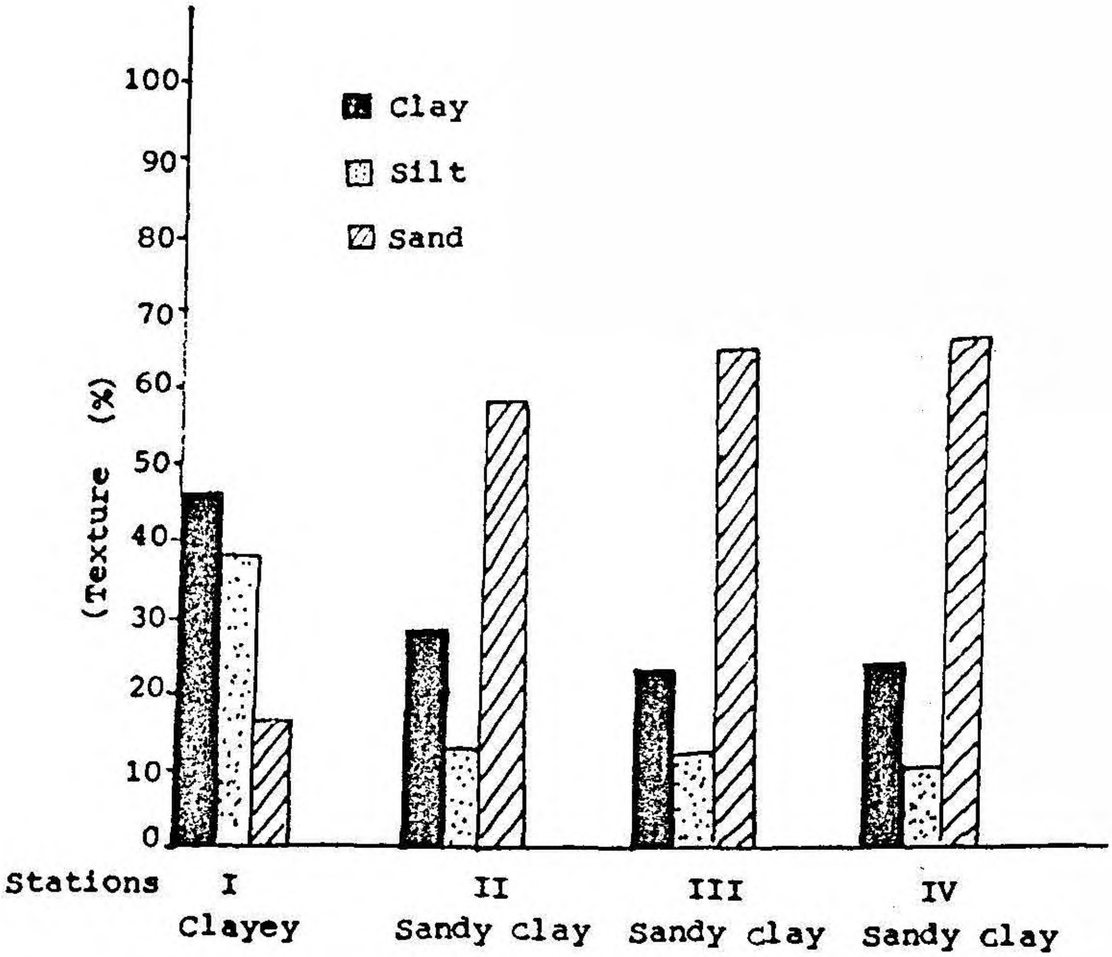
The grain size analysis has revealed two textural classes of soil in the four stations. The pokkali fields at Cherai showed a clayey texture.

For the Narakkal coconut groves, the CIBA experimental pond and the CIBA supply canal, the grain have shown a sandy texture. In each of the ecosystem during the period of study, no appreciable seasonal variations in the grain size or texture was observed (Table 9), (Fig.2).

Table 9: Grain size analysis of soil.

Stations	Clay	Silt	Sand	Texture
I. Cherai Pokkali fields	46	38	16	Clayey
II. Narakkal Coconut groves	28.8	12.6	58.6	Sandy Clay
III. CIBA experimental pond	23.6	10.6	65.6	Sandy Clay
IV. CIBA supply canal	23.8	10.2	67.0	Sandy Clay

Fig. 2 Distribution of grain size at different Stations.



BIOLOGICAL PARAMETERS

Major "Lab-Lab" constituents:

The main "Lab-Lab" constituents observed in the four stations are : *Oscillatoria* spp., *Phormidium* spp, *Lyngbya* spp, *Spirulina* spp, *Pleurosigma* spp, *Navicula* spp, *Nitzschia* spp, *Amphora* spp, and *Coscinodiscus* spp. The major microfauna observed are: Amphipods, Copepods, Polychaeteworms, and Lamellibranch spats.

The number and abundance of individual groups of "Lab-Lab" constituents and their total quantity in Cherai Pokkali fields, Narakkal coconut groves, CIBA experimental pond and CIBA Supply canal are given in Tables No.10, 11, 12 and 13 respectively.

In Cherai pokkali field the total quantity of "Lab-Lab" (algal complex and microfauna) has gradually increased from April and attaining a peakin May III week amounting to 18380/100 cm^2, it has declined to 2668 in June due to the onset of monsoon. The abundance of species was less during the monsoon period of June and July, but from August onwards, it has gradually shown an increasing trend. The minimum quantity was observed in June Ist week (2668/100 cm^2) and the maximum (78580/100 cm^2) was observed in September III week (Fig.3).

In Narakkal coconut grooves the quantity of "Lab-Lab" varied between 1,970 and 89,970/100 cm^2. In April the total production was 14,120/100 cm^2 and it gradually increased and reached a peak in May (18340/100cm^2). The total production has declined to 1,970/100cm^2 in June probably due to the onset of the monsoon; and as the effect of monsoon receeded, the production has gradually increased and the reached a maximum inSeptember third week,to 89770/100cm^2 (Fig. 3).

In CIBA experimental pond the total production has varied between 2795 and 68705/100cm^2, with minimum (2795/100cm^2) in June first week and maximum in September third week (Fig. 3).

In the CIBA Supply canal, the total production showed a fluctuation between 4,550 and 50,475/100cm^2. The lowest production was observed in June first week and the maximum was in September third week (Fig. 3).

Blue-green algae and diatoms:

(i) *Oscillatoria* spp.

In Cherai pokkali fields, the number of *Oscillatoria* filaments present during the period of study was estimated to have a mean of 1658/100cm^2, and their length ranged from 0.198 mm to 0.297 mm, with the mean at 0.247 mm. The production was computed at 409 mm/100cm^2 (Table 14). The number of

Fig. 3 Variation in total production of "Lab-Lab" at different stations during April - October 1991.

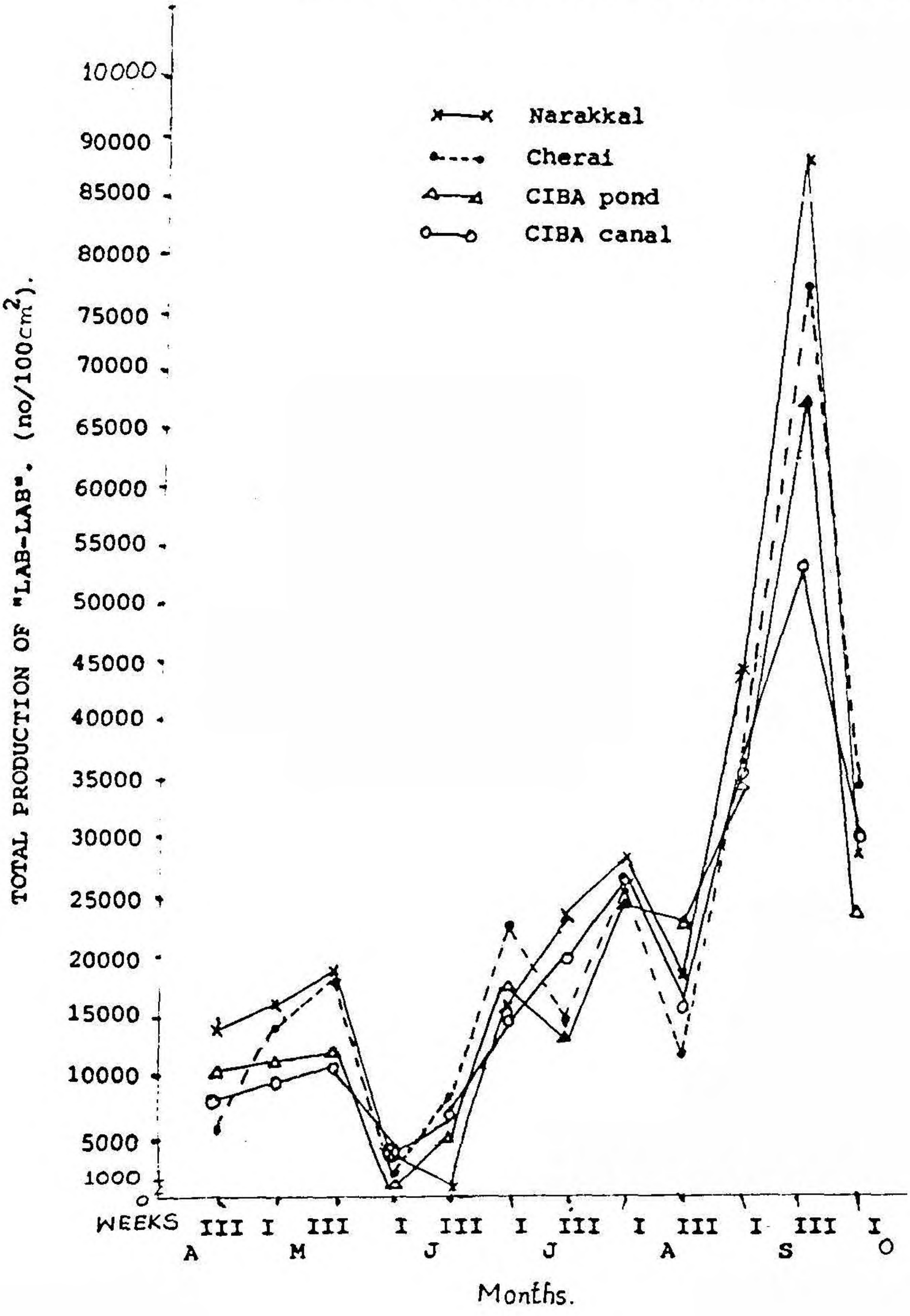


Table 10. Distribution and abundance of "Lab-Lab" constituents in Cherai pokkai fields (Station I) during April - October 1991.

Seasons	Months	Weeks	Oscillatoria.	Phormidium	Lyngbya	Spirulina	Pleurosigma.	Navicula	Amphora	Nitzschia	Coscinodiscus	Amphipod.	Copepod.	Polycheate-worms.	Lamellibranch spat.	Total
Pre-Monsoon	April	III	300	1000	200	200	1000	400	1700	300	400	30	35	20	-	5,585
	May	I	400	11100	1000	-	3600	1100	4000	2100	800	50	60	40	-	14,250
		III	800	2100	1500	100	3800	2000	4500	2400	1000	80	40	60	-	18,380
Monsoon	June	I	400	100	300	-	500	300	400	100	100	68	30	20	-	2,668
		III	500	100	600	100	1600	600	1800	300	100	50	40	30	-	5,820
	July	I	-	100	2500	-	7500	7500	2800	2500	100	60	30	20	200	23,210
		III	2000	5000	-	2000	1000	1000	1000	2800	50	200	30	50	100	15,320
	August	I	3000	7500	-	-	1000	7500	7500	-	100	75	20	30	120	26,845
		III	-	-	-	-	2500	2500	5000	-	2500	50	10	20	80	12,660
Post-monsoon	September	I	-	5000	-	2500	5000	7500	15000	2500	-	30	20	30	-	37,580
		III	7500	2500	2500	-	22500	25000	17500	1000	-	30	20	30	-	78,580
	October	I	5000	1000	1000	-	5000	10000	8000	5000	-	15	10	20	-	35,045

Oscillatoria filaments ranged between 300 and 7500/100cm^2 and the maximum production was observed in September third week. No algal filament was found in the samples collected in July first week, August third week and September first week (Table 10).

In Narakkal coconut groves, the number of filaments during the period of study was estimated to have a mean of of 6366/100cm^2 and their length ranged from 0.204 mm to 0.324 mm with the mean at 0.264 mm. The production was computed as 1680 mm/100cm^2 (Table 14). The number of filaments/100cm^2 ranged between 100 and 2200/100cm^2 and the minimum was observed in July and the maximum was observed in September third week (Table 11).

In the CIBA experimental pond, *Oscillatoria* had an estimated mean of 4558/100cm^2 and their length ranged between 0.201 to .282 with mean at 0.241. The production was computed at 1098 mm/100cm^2 (Table 14). The number of filaments/100cm^2 ranged between 2,795 and 68,705/100cm^2. The minimum was observed in June first week and the maximum number was in September third week (Table 12).

In CIBA Supply canal, the number of Oscillatoria filaments during the period of study was estimated to have a mean of 2175/100cm^2 and their length ranged from 0.162 to 0.198 mm, with the mean at 0.180 mm. The production was computed as 391 mm/100cm^2 (Table 14). The total number of filaments showed a fluctuation between 100 and 7500/100cm^2 during the period of study. The lowest number was observed in June first week and maximum number was noticed in August first week (Table 13).

The total number of Oscillatoria spp. for Cherai pokkali fields and Narakkal coconut groves is seen differing significantly between them (Table 22).

(ii) Phormidium spp.

In Cherai pokkali fields, the number of Phormidium filaments during the period of study was estimated to have a mean of 2125/100 cm^2 and their length ranged from 0.162 and 0.320mm with a mean value of 0.241 mm. The production has amounted to 512mm/100cm^2 (Table 15). The total number of filaments/100cm^2 ranged between 100 to 7500 the minimum being in June and July, and the maximum in August.

In Narakkal coconut groves the number of Phormidium filaments during the period was estimated to have a mean of 2966/100cm^2 and their length ranged from 0.192 to 0.342 mm with the mean at 0.267 mm. The production has amounted to 791mm/100cm^2 (Table 15). The total number of filaments/100cm^2 ranged between 100 and 7500/100cm^2. The number of filaments/100cm^2 has gradually increased from

Table 11. Distribution and abundance of Lab-Lab constituents in Narakkal coconut groves (Station II) during April - October 1991.

Seasons	Months	Weeks	Oscilla-toria	Phorm-idium	Lyn-gbya	Spiru-lina	Pleuro-sigma	Navi-cula	Amph-ora	Nitz-schia	Coscin-odis	Amph-ipod.	Cep-epod.	Poly-chaete-worms.	Lame-lli-branch sp-at.	Total
Pre-Monsoon	April	III	1200	1200	700	300	8300	1000	400	800	100	40	50	30	-	14,120
	May	I	1400	1400	1800	400	10000	300	600	300	200	60	80	40	-	16,580
		III	1800	1600	2000	600	10200	400	800	400	300	80	100	60	-	18,340
Mon-soon	June	I	400	800	200	-	1100	600	700	100	100	40	30	20	-	4,090
		III	100	100	100	-	1000	200	200	100	100	30	20	20	-	1,970
	July	I	3000	7500	-	-	1000	2500	2500	50	100	40	30	50	30	16,800
		III	4000	7500	-	-	4000	3000	1500	3000	1000	30	50	20	40	24,140
	August	I	5000	5000	-	-	7500	7500	2500	1000	1000	40	60	80	80	29,760
		III	2500	2500	-	-	7500	1500	3000	1000	1000	80	60	100	120	19,360
Post-Monsoon	Septe-mber	I	20000	2500	2500	-	8000	5000	4000	2500	500	80	80	120	40	45,320
		III	22000	3500	1000	-	7500	22500	20600	12500	600	100	120	130	20	89,970
	October	I	15000	2000	2000	-	4000	3000	2000	1200	400	80	60	90	10	29,790

April and after attaining a peak in May third week (1600/100 cm^2), it has declined to 100/100cm^2 during the monsoon i.e. in June third week. The maximum number of _Phormidium_ was observed in Jnly. After July, again it has shown a declining trend.

In the CIBA experimental pond, the number of _Phormidium_ filaments was estimated to have a mean of 3375/100cm^2 and their length ranged from 0.214 to 0.352 with the mean at 0.283 mm. The production has amounted to 955 mm/100cm^2 (Table 15). The total number of filaments/100cm^2 ranged between 400 and 8000/100cm^2. The minimum was observed in June and the maximum was observed in September third week.

In the CIBA Supply canal, the number of _Phormidium_ filaments, was estimated to have a mean of 2875/100cm^2, and their length ranged from 0.189 to 0.332 mm with the mean at 0.260mm. The production was amounted to 748 mm/100cm^2(Table 15). The total number of filaments/100cm^2 ranged between 400 to 7500/100cm^2. The lowest number was observed in May first week and maximum was in August first week.

(iii) _Lyngbya_ spp.

In Cherai Pokkali fields, the total number of _Lyngbya_ filaments, during the period of study was estimated to have a mean of $800/100cm^2$ and their length ranged from 0.132 to 0.178 mm with the mean at 0.155 mm. The production has amounted to $124mm/100cm^2$ (Table 16). The total number ranged between 200 and $2500/100cm^2$, with the lowest number in April and the highest in July and September (Table 10).

In Narakkal coconut groves, the total number was estimated to have a mean of $708/100cm^2$ and their length ranged from 0.122 to 0.158 mm with the mean at 0.140mm. The production has amounted to $99mm/100cm^2$ (Table 16). The total number ranged between 100 and $2500/100cm^2$, with the lowest in June and the highest in September first week. In July and August the *Lyngbya* spp. were absent in the collection.

In the CIBA experimental pond, the total number was estimated to have a mean at $650/100cm^2$ and their length ranged between 0.132 and 0.172 mm with the mean at 0.152mm. The production has amounted to $98mm/100cm^2$ (Table 16). The total number ranged between 300 and $2800/100cm^2$ during the period with the lowest in June first week and the highest in July first week. After July first week, *Lyngbya* spp. was almost absent in the collection.

In the CIBA supply canal, the total number was estimated to have the mean at $1541/100cm^2$ and their length ranged between 0.152 to 0.218mm with the mean at 0.185mm. The production

Table 12. **Distribution and abundance of "Lab-Lab" Constituents in the CIBA experimental pond (Station III) during April-October 1991.**

Seasons	Months	Weeks	Oscill-atoria	Phormi-dium	Lyngb bya	Spru-lina	Pleuro-sigma	Navi-cula	Amph-ora	Nitz-schia	Cosci-nodis-cus	Amph-ipod	Cope-pode	Poly-chaet-eworms	Lame-lli Branch Spat.	Total
Pre-Monsoon	April	III	800	1000	800	2800	1400	700	1500	700	600	45	50	30	--	10,425
	May	I	900	1200	1200	3000	1200	900	1400	800	700	50	80	40	-	11,470
		III	1000	1100	1300	3500	1300	1200	1500	900	800	60	60	80	-	12,800
Monsoon	June	I	200	400	300	-	400	300	200	800	100	30	40	25	-	2,795
		III	300	400	500	500	600	500	600	1400	600	40	60	30	-	5,530
	July	I	2500	2500	2800	-	600	2500	6000	800	100	60	150	35	200	18,245
		III	-	7500	-	-	1500	1500	1000	2600	100	50	80	30	130	14,490
	Aug.	I	-	7500	-	5000	5000	7000	1000	100	100	30	60	60	100	25,950
		III	2500	5000	-	-	7500	4000	4000	50	50	40	20	30	50	23,240
Post-Monsoon	Sept.	I	20000	5000	-	-	7500	6000	5000	100	-	30	30	20	-	40,680
		III	22000	8000	-	-	20000	8500	10000	100	-	40	30	35	-	68,705
	Oct.	I	4000	9000	900	-	4000	8000	6000	400	-	20	20	20	-	24,260

has amounted to 285mm/100cm^2. The total number varied between 400 and 7500/100cm^2, with the lowest in June first week and the highest in July third week.

(iv) Spirulina spp.

In Cherai pokkali fields, the number of Spirulina has ranged between 100 and 2500/100cm^2 and the lowest observed in May and June and the highest number observed in September first week (Table 10). In Narakkal coconut grooves, the total number has varied between 300 and 600/100cm^2 during the period of study with the lowest in April and the highest in May third week. After May, this group was not present in the collections (Table 11). In the CIBA, experimental pond, the total number has fluctuated between 500 and 3500/100cm^2 with the lowest in June third and the highest observed in May third week. In the CIBA Supply canal, this group has shown variation between 2500 and 2800/100cm^2, with the maximum in May third week. After May, the species was almost absent in the collection until August.

Statistically Spirulina spp. has shown significant variation between station II and III, Narakkal coconut groves and CIBA experiment pond (Table 20).

(v) Pleurosigma spp.:

In Cherai pokkali fields, the total number of Pleurosigma varied between 500 and 22500/100cm^2, with the lowest in June and the highest number in September third week. In Narakkal coconut groves, the total number varied between 1000 and 10,200/100cm^2 with the maximum in May third week and the minimum in June third and July first week (1000/100cm^2). In the CIBA experimental pond, the total number ranged between 400 and 20,000/100cm^2 with the maximum in September third week and the minimum was observed in June first week. In the CIBA supply canal, the total number ranged between 500 and22000 /100cm^2 with the maximum in September third week and the minimum (500/100cm^2) in June.

(vi) Navicula spp:

In Cherai pokkali fields, the abundance of Navicula spp. varied between 200 and 25000/100cm^2 during the period, with the lowest in June third week and the highest in September third week. In Narakkal coconut groves, the total showed a fluctuation between 300 and 22500/100cm^2 with the lowest during June and the highest number during September. The CIBA experimental pond, the total number varied between 300 and 2500/100cm^2 with the minimum in June first week and the maximum in September third week.

Table 13. Distribution and abundance of Lab-Lab constituents in the CIBA supply canal (Station IV) during April - October 1991.

Seasons	Months	Weeks	Oscillatoria.	Phormidium	Lyngbya	Spirulina	Pleurosigma.	Navicula	Amphora	Nitzschia	Coscinodiscus	Amphipod.	Copepod.	Polychaete-worms.	Lamellibranch spat.	Total
Pre-Monsoon	April	III	400	800	600	2700	1800	800	900	300	500	30	35	30	-	8895
	May	I	1200	400	800	2600	2000	900	500	800	400	50	95	80	-	9825
		III	900	600	1200	2800	2400	1000	1000	900	600	40	60	60	-	11560
Monsoon	June	I	100	1500	400	-	500	500	1000	600	800	30	85	35	-	4550
		III	2000	1500	1500	-	500	400	1000	500	200	100	60	70	-	7800
	July	I	2500	4000	5000	-	600	500	1200	800	400	60	40	30	100	15230
		III	3500	6000	7500	-	800	700	1000	1000	100	70	30	80	120	20370
	August	I	7500	7500	-	-	900	2500	2500	700	300	20	70	60	80	27100
		III	-	5000	-	-	1000	3000	6000	900	100	30	60	15	-	16105
Post-Monsoon	September	I	2500	2500	-	2500	1600	4000	8000	1000	200	35	80	30	-	36845
		III	3500	3700	1000	-	22000	5000	10000	5000	200	30	30	15	-	50475
	October	I	2000	2000	1000	-	10000	2000	9000	4000	100	20	20	10	-	30150

In the CIBA canal the total number showed fluctuation between 400 and 5000/100cm^2 with the highest in September third week and the lowest in June third week.

(vii) Amphora spp:

In Cherai pokkali fields the total number showed a fluctuation between 400 and 17500/100cm^2 with the minimum in June first week and the maximum in September third week. In Narakkal coconut groves, its total number varied between 200 and 20600/100cm^2 with the highest in September third week and the lowest in June third week. In the CIBA experimental pond the total number showed a fluctuation between 200 and 10,000/100cm^2 with a minimum in June first week and the maximum in September third week. In the CIBA Supply canals, the total number varied between 500 and 10,000/100cm^2 with the lowest in May, first week and the highest in September third week.

(viii) Nitzschia spp:

In Cherai pokkali fields the total number of Nitzschia showed a fluctuation between 100 and 5000 with the maximum in October first week and the minimum in June. This Spp was absent in the month of August. In Narakkal coconut groves the total number showed a fluctuation between 50 and 12500/100 cm^2 in the July first week and the highest in September third week. In the CIBA experimental ponds its total number ranged between 50 and 2600/100 cm^2, with the minimum in August third week and maximum was observed in July third week. In the CIBA canal, total number ranged between 300 and 5000/100 cm^2, with the maximum in September third week and the minimum in April.

(ix) Coscinodiscus spp.

In Cherai pokkali fields, the maximum number (2500/100 cm^2) was observed in August third week and the group was absent in the collection of September to October. The minimum (50/100 cm^2) was observed in July third week. In Narakkal coconut groves, the number ranged between 100 and 1000/100 cm^2 with the minimum number in June I, III weeks and July first week and the maximum in the month of August. In the CIBA experimental pond the number varied between 50 and 800/100 cm^2 area with the maximum number in May third week. In September and October this group was absent in the collection. The minimum was observed in the CIBA supply canal, the total number showed a fluctuation between 100 and 800, with the lowest in July third week, August third week and October and the maximum in June first week.

Table 14. Production of *Oscillatoria* spp (in mm) at different stations during April - October 1991

Stations	Estimated No. of filaments (mean value)	Mean length of filaments (mm)	Estimated length filaments/100 cm^2 (mm)
I. Cherai pokkali fields	1658	0.247	409
II. Narakkal coconut groves	6366	0.264	1680
III. CIBA experimental pond	4558	0.241	1098
IV. CIBA supply Canal	2175	0.180	391

Table 15. Production of *Phormidium* spp (in mm) at different stations during April-October 1991.

Stations	Estimated No. of filaments (mean value)	Mean length of filaments (mm)	Estimated length of filaments/ 100 cm^2(mm)
I. Cherai pokkali fields	2125	0.241	512
II. Narakkal coconut groves	2966	0.267	791
III. CIBA experimental pond	3375	0.283	995
IV. CIBA supply canal	2175	0.180	391

Table 16. Production of *Lyngbya* spp (in mm) at different stations during April-October 1991.

Stations	Estimated No. of filaments (mean value)	Mean length of filaments (mm)	Estimated length of filaments/ 100 cm^2 (mm)
I. Cherai pokkali fields	800	0.155	124
II. Narakkal coconut groves	708	0.140	99
III. CIBA experimental pond	650	0.152	98
IV. CIBA supply canal	1541	0.185	285

Microfauna

(i) Amphipods:

In Cherai pokkali fields their total number has varied between 15 and 200/100 cm^2 with the maximum in July third week and the minimum in October first. In Narakkal coconut groves, the total showed a fluctuation between 30 and 100/100 cm^2 area with the maximum in September third week and the minimum in June & July third weeks. In the CIBA experimental pond, the total number ranged between 20 and 60/100 cm^2 with the highest in May third week and the lowest in October first week. In the CIBA supply canal, the total number showed a fluctuation between 20 and 100 with the maximum in June third week and the minimum in August first and October first weeks.

(ii) Copepods:

In Cherai Pokkali fields the total number showed a fluctuation between 10 and 60/100 cm^2 area with the maximum number in May III week and the minimum in August third and October first weeks. In Narakkal coconut groves the number ranged between 20 and 120/100 cm^2 area with the maximum number in May third week (Pre-monsoon) and the minium in June third week (Monsoon period). In the CIBA experimental pond, the number varied between 20 and 150 with the maximum in July first week and the minimum in August third and October first weeks. In the CIBA supply canal, the number showed a fluctuation between 20 and 95 with the highest in May first week and the lowest in October first week.

Copepods is a major group of organisms which showed a significant differences between the stations i.e. the Cherai Pokkali fields and Narakkal coconut groves (Stations I and II) Cherai Pokkali fields and CIBA canal (Stations I and IV) Narakkal coconut groves and the CIBA experimental pond (Stations II and III) and the CIBA experimental pond and the CIBA supply canal (Stations III and IV). (Table 20).

(iii) Polychaete worms:

In Cherai Pokkali fields their total number varied between 20 and 60/100 cm^2 areas, with the maximum number in the postmonsoon period i.e. in the third week of May; and after attaining the peak it has gradually decreased in the monsoon period with the lowest number in June first week (monsoon period). In Narakkal coconut groves the total number showed a fluctuation between 20 and 130 with the lowest in monsoon period i.e. in the month of June and the highest in the post-monsoon period i.e. in the month of September. In the CIBA experimental pond, the number varied between 20 and 80/100 cm^2 area with the maximum in May third week. After that, number showed a declining trend in the monsoon period with the lowest in September first and October first week. In the CIBA supply canal, the total number fluctuated between 10 and 80/100 cm^2 area with the maximum in May first week and the minimum in October first week.

Statistically, the total number of polychaete worms showed significant variations between Cherai pokkali fields and Narakkal coconut groves (Stations I and II) and, Narakkal coconut groves and CIBA experimental pond (Stations II and III). (Table 20).

(iv) Lamellibranch spat:

In Cherai pokkali fields it was present only in the month of July and August with a peak of 200/100 cm^2 in July first week and with the lowest number of 80/100 cm^2 in August third week. In Narakkal coconut groves, it was present from July to October with the maximum number of 120/100 cm^2 in August and the minimum of 10/100 cm^2 area in October first week. Inthe CIBA experimental pond, it was present only in July and August with the maximum in July I week (200/100 cm^2 area) and the minimum in August third week (50/100 cm^2 area).

In the CIBA supply canal it was present only in July and August. The highest of 120/100 cm^2 area was observed in July third week and the lowest of 80/100 cm^2 area was in August first week.

Co-relation study

After anova analysis of values, the significant differences between the stations for individual parameters, both environmental and biological have been found out. The same were also plotted for graphical representation, vide Figs. 4 through 10. The environmental parameters showing significant differences between the stations and the biological values showing the same are co-related and the following conclusions are drawn.

1. *Oscillatoria* spp showed a positive relationship with dissolved oxygen in Cherai pokkali fields (Station I) but no such definite relationship can be drawn fot it with soil organic matter and water phosphates (Fig. 4).

2. In Cherai pokkalifields, copepods showed a positive relationship with organic matter, dissolved oxygen and water phosphates. Positive relation ship has also been obtained between polychaete worms and soil organic matter (Fig. 5).

3. *Spirulina* spp is positively co-related to dissolved oxygen; in Narakkal coconut groves. A similar relationship

Fig. 4 Relationship of *Oscillatoria* spp with dissolved oxygen, water phosphate and soil organic matter at Station No. I, Cherai pokkali fields.

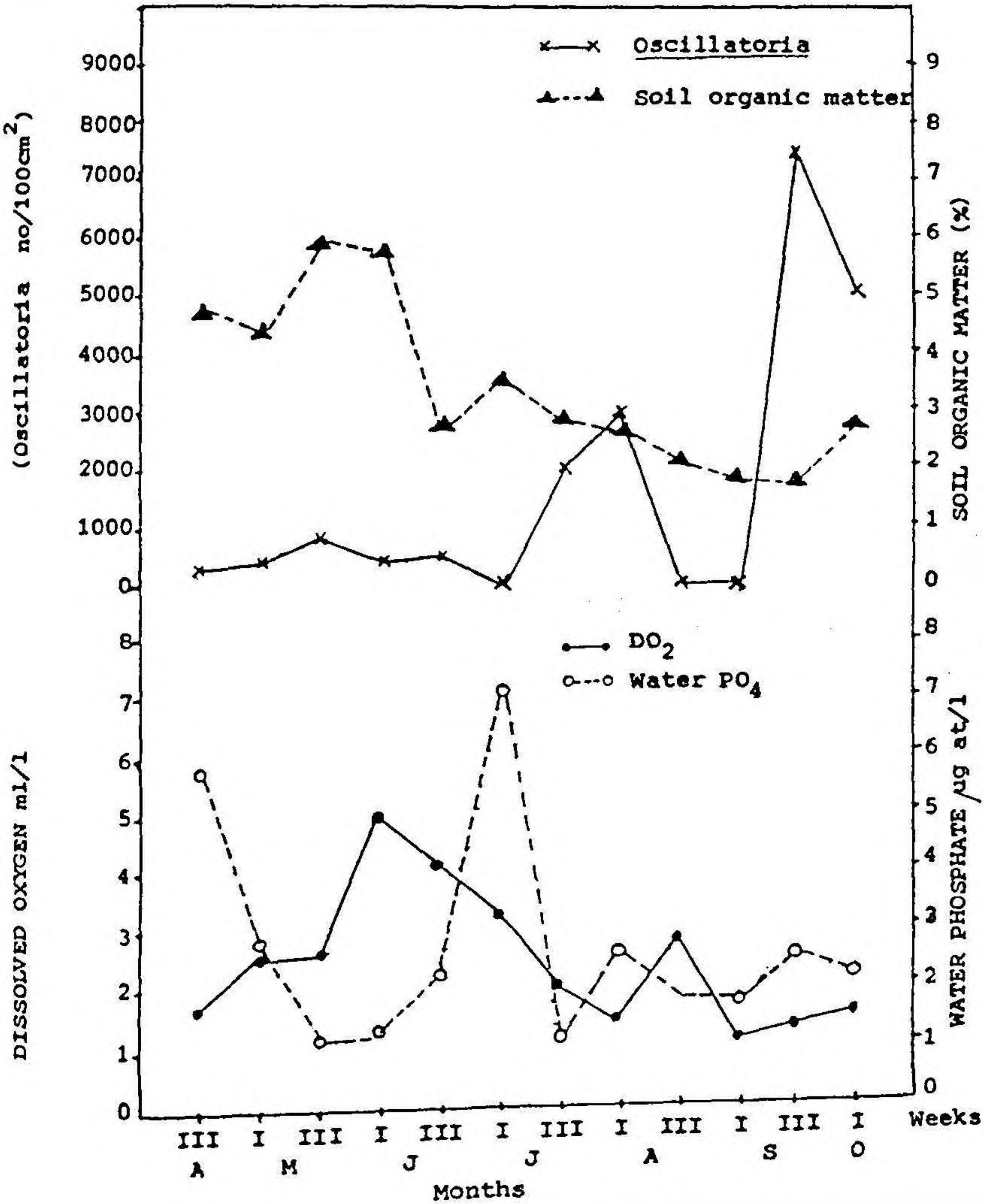
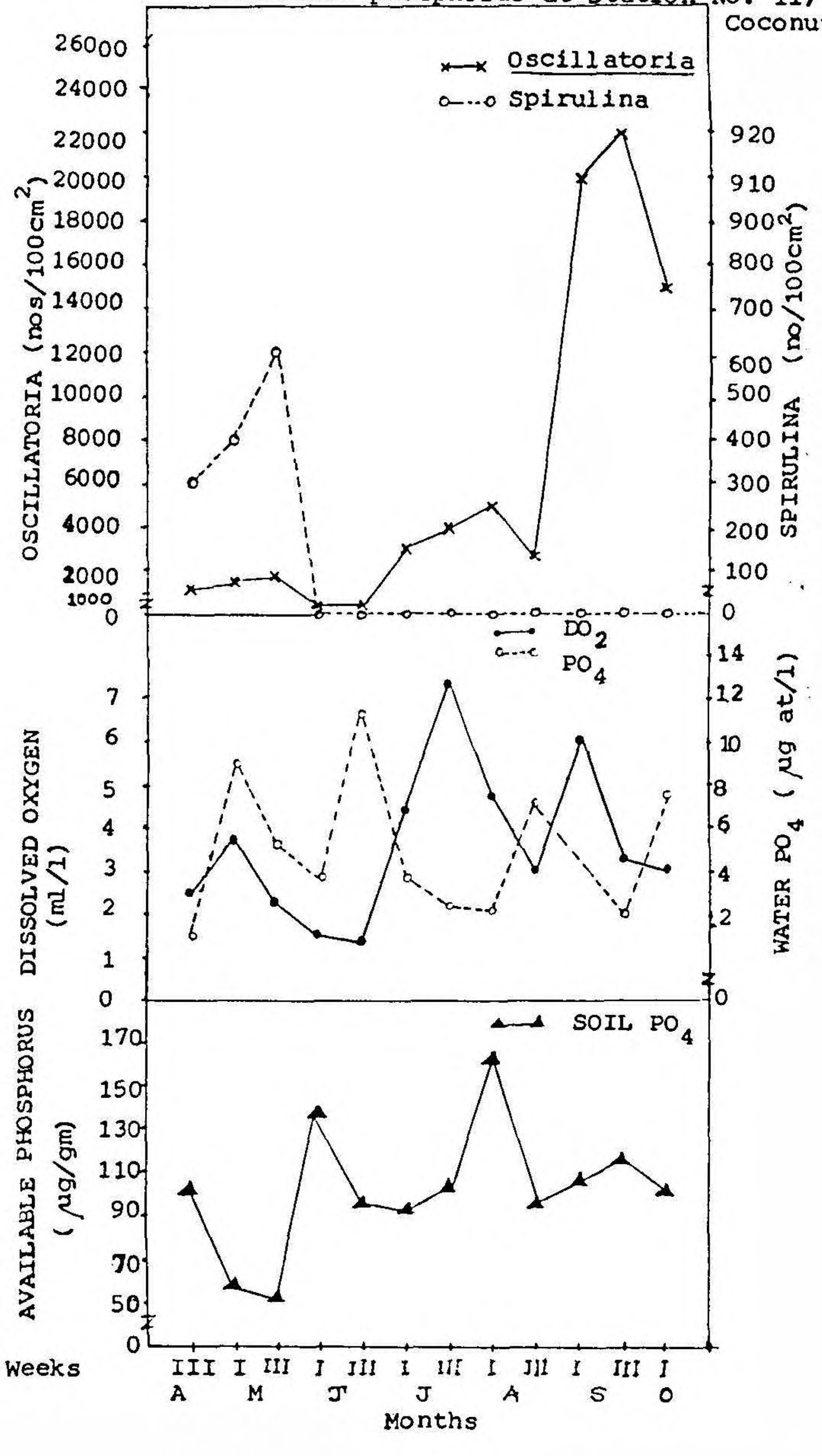


Fig. 6 Relationship of Oscillatoria spp and Spirulina Spp with dissolved oxygen, water phosphate and available phosphorus at Station No. II, Narakkal Coconut groves.



has also been obtained for Oscillatoria spp (Fig: 6).

4. Among the microfauna, copepods showed a positive relationship with water phosphates in Narakkal coconut groves (Fig: 7).

5. Spirulina spp is positively co-related to dissolved oxygen in the CIBA experimental pond (Fig: 8) and the abundance of polychaete worms is directly related to soil phosphates. (Fig: 9).

6. In the CIBA supply canal, copepods showed a positive relationship with organic matter. But no definite relationship has been obtained for water phosphates (Fig. 10).

Also, Linear regression analysis between total "Lab-Lab" production and the environmental parameters gave the following relationship vide Table 23.

In Cherai pokkali fields, rainfull and dissolved oxygen showed a negative relationship with total Lab-Lab production ($p < 0.05$), whereas temperature, salinity, pH, free Co_2, Nitrate, phosphate, organic carbon, organic matter total nitrogen and available phosphorous showed a positive relationship. Among these, only salinity, temperature, organic matter, total nitrogen and available phosphorus showed a significant relationship ($p < 0.05$) with "Lab-Lab" production (Fig. 11 & 12).

Fig. 7 Relationship of Copepod and Polychaete worms with dissolved oxygen, water phosphate and available phosphorus at Station No. II, Narakkal Coconut groves.

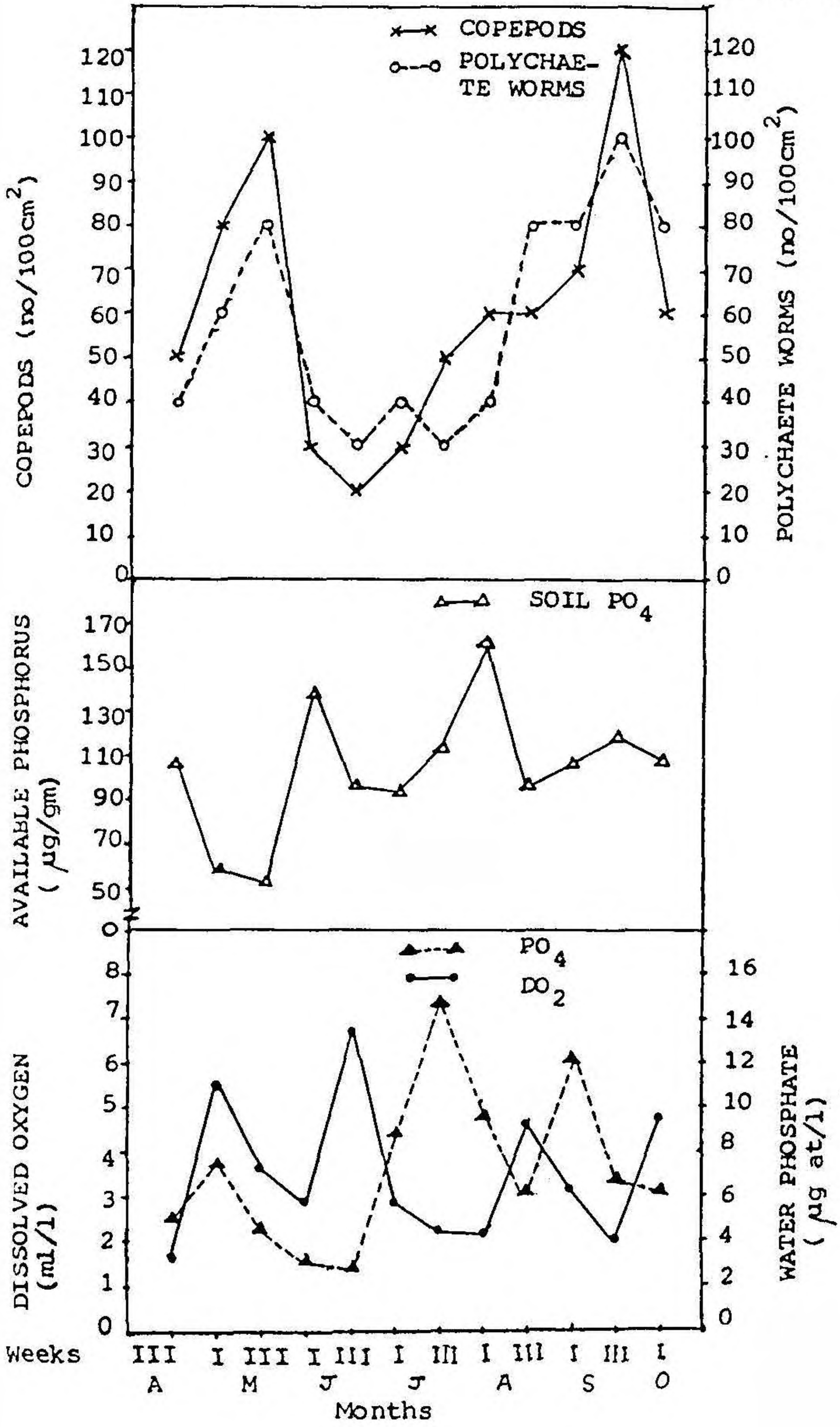


Fig. 8 Relationship of Spirulina spp with dissolved oxygen, water phosphate and available phosphorus at Station No. III CIBA experimental pond.

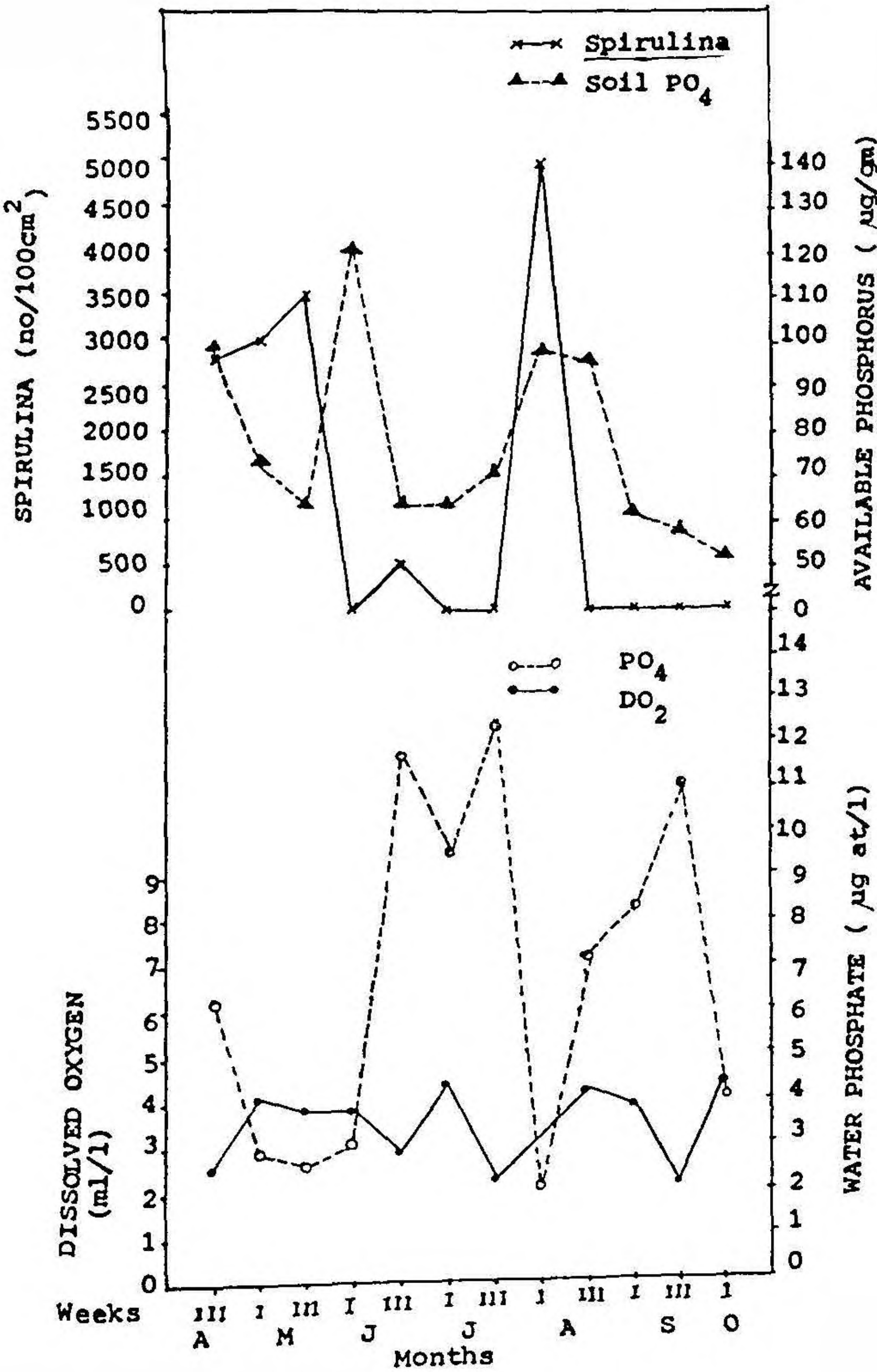


Fig. 9 Relationship of Copepod and Polychaete worms with dissolved oxygen, water phosphate and available phosphorus at Station No. III CIBA experimental pond.

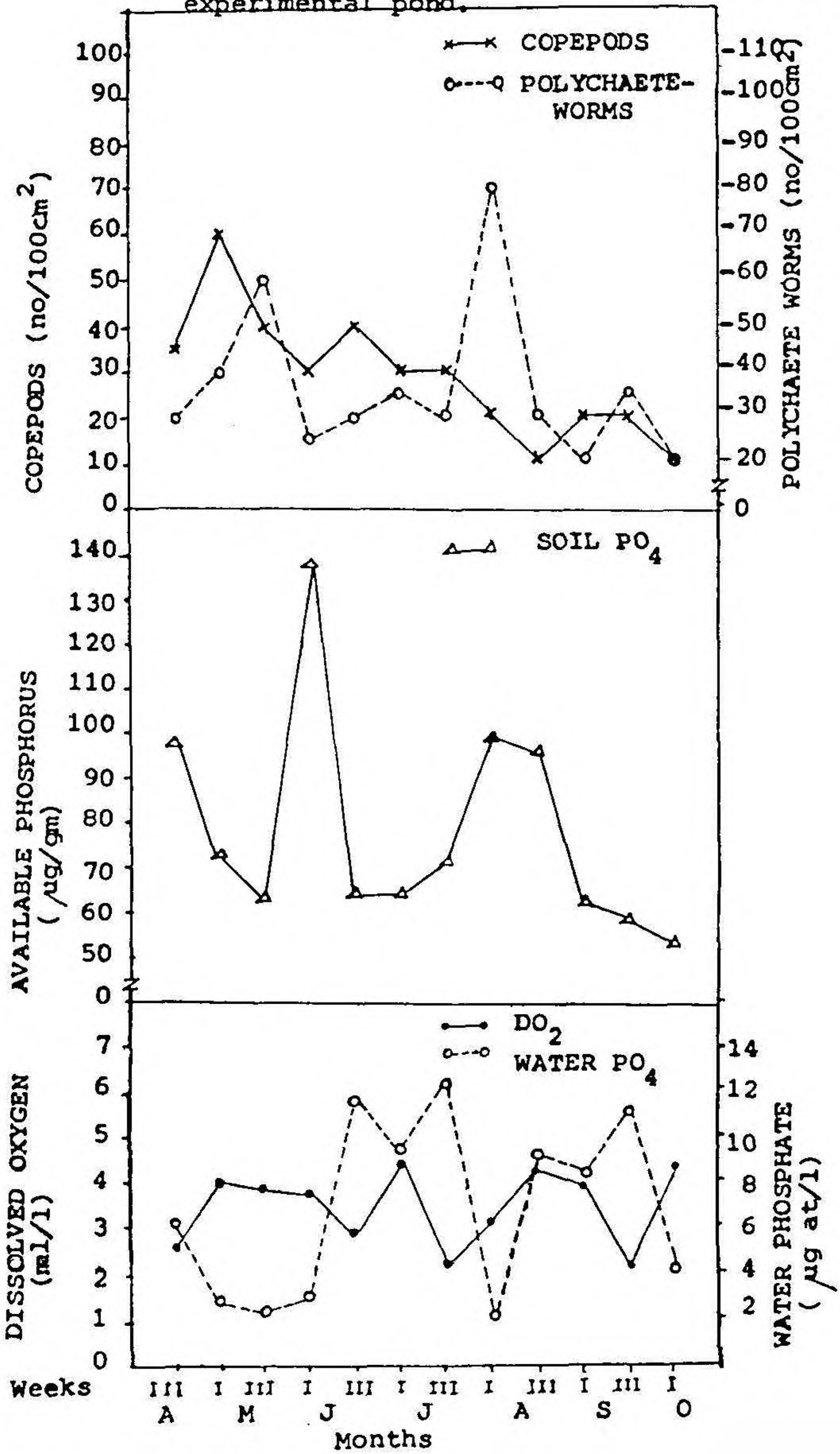


Fig. 10 Relationship of Copepod with water phosphate and soil organic matter at Station No. IV, CIBA supply canal.

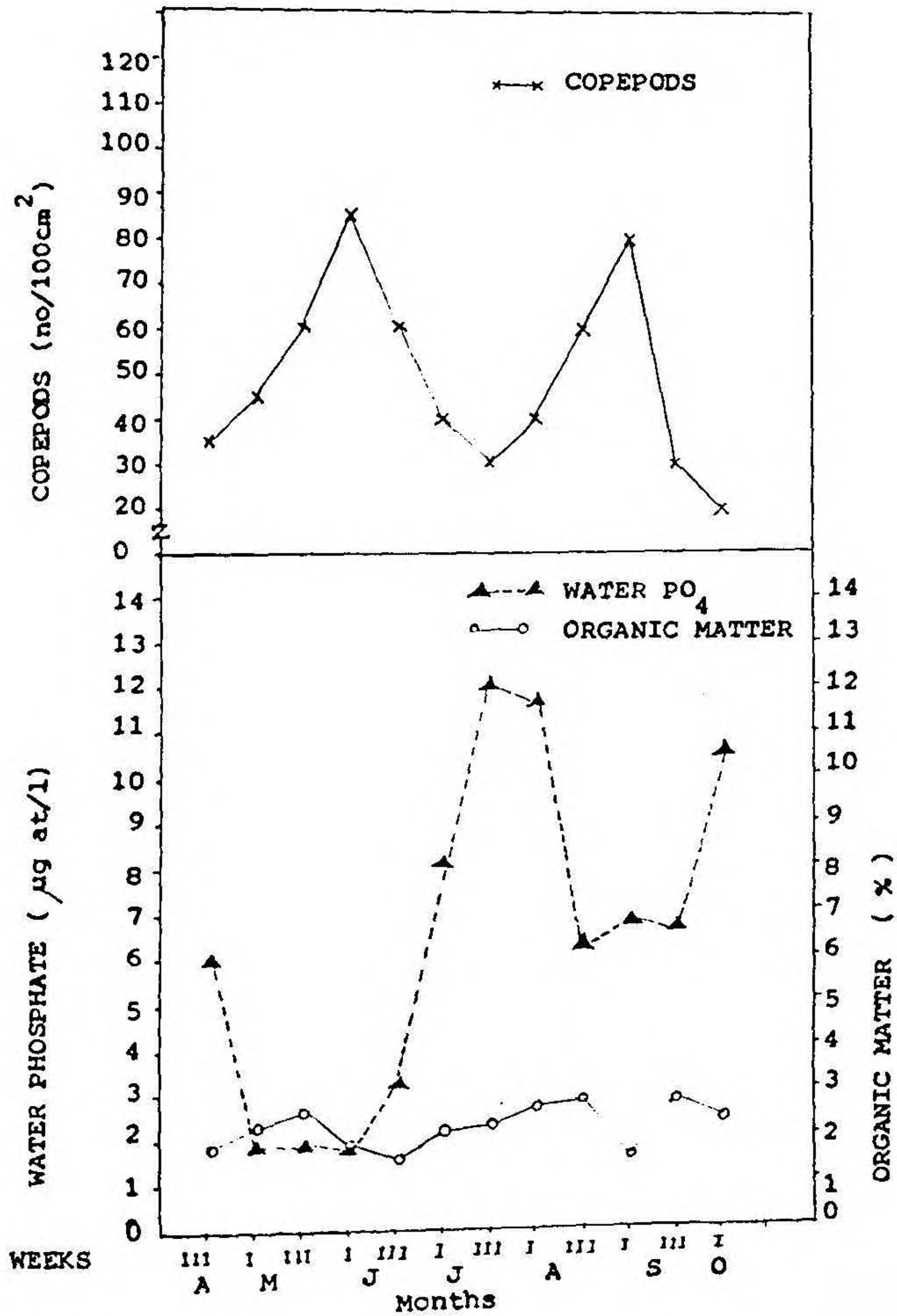


Fig. 11 Influence of rainfall, temperature, salinity and dissolved oxygen on "Lab-Lab" production at Station No. I, Cherai pokkali fields.

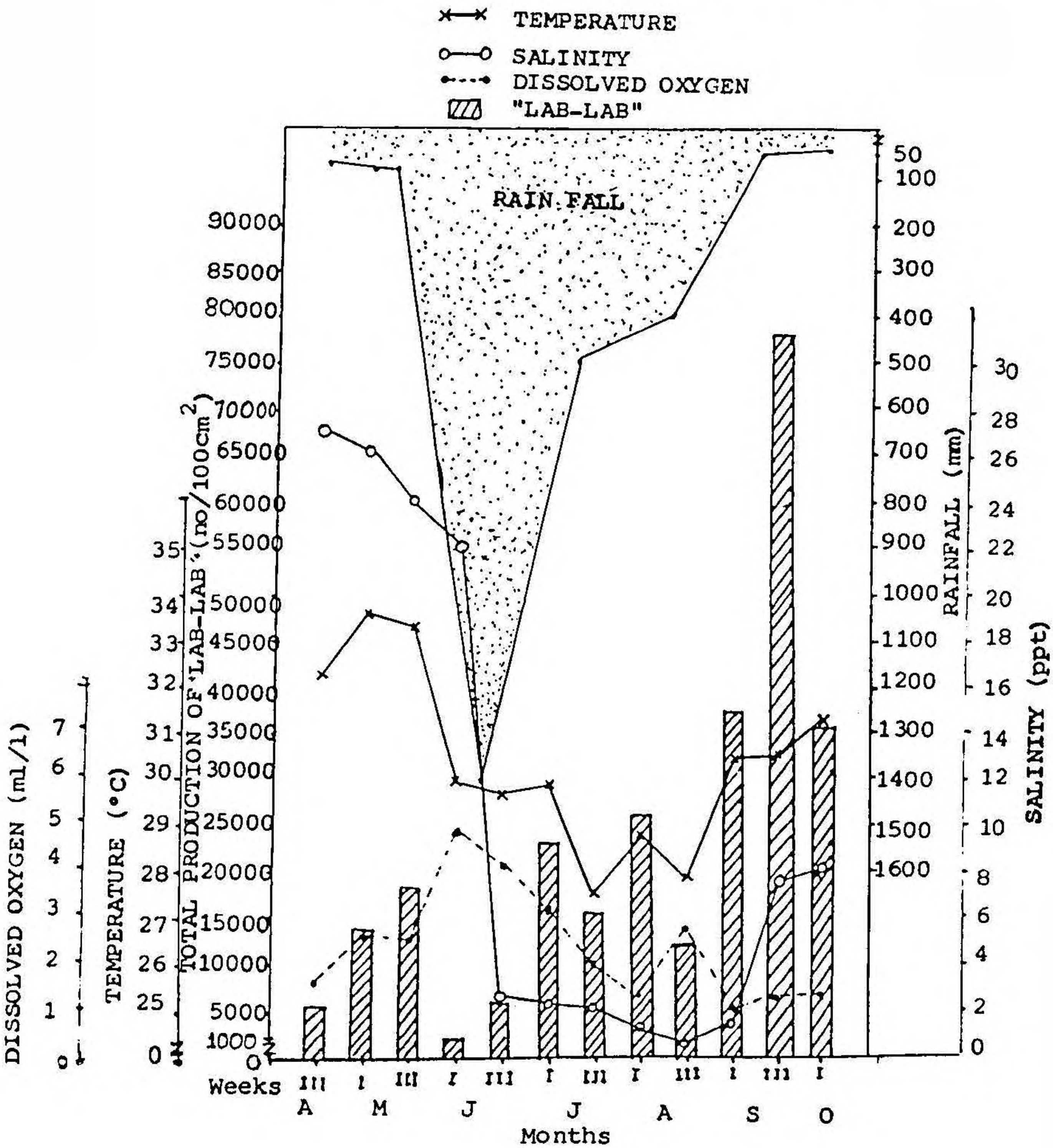
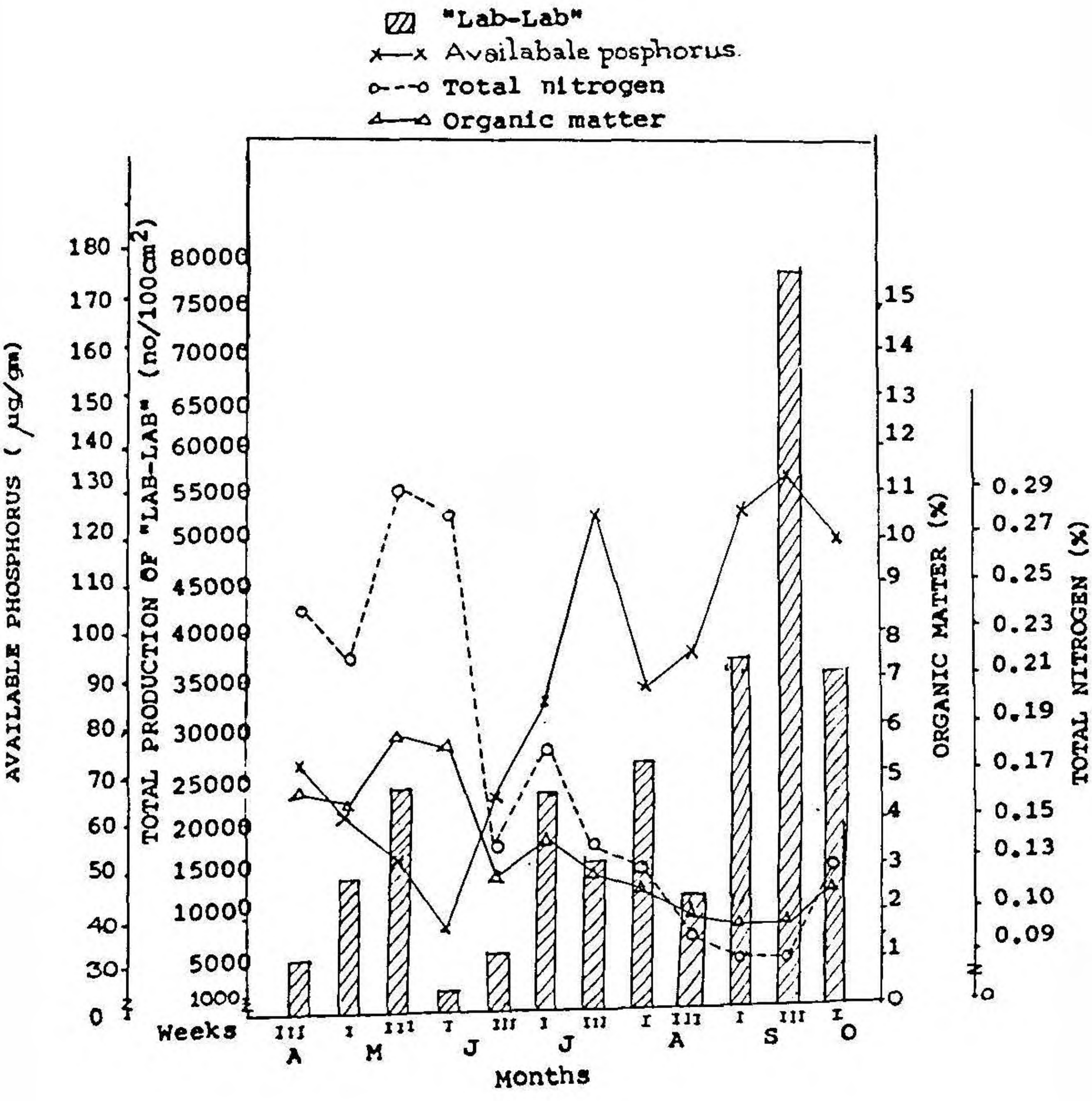


Fig. 12 Influence of Sedimentological parameters on the production of "Lab-Lab" at Station No. I, Cherai Pokkali fields.



In Narakkal coconut groves, "Lab-Lab" production is negatively significant to rainfall with r = $\overline{0}$ .69 ($p < 0.05$). Dissolved oxygen also showed a negative relationship but no significant role can be noticed.

In this station, the temperature, salinity, water-phosphates, organic matter, total nitrogen and available phosphorus showed a positive relationship with Lab-Lab production at 5% level. pH, Nitrate and organic carbon also showed a positive relationship but is not significant (Figs. 13 & 14).

In the CIBA experimental pond, rainfall has shown a negatively significant relationship with the total Lab-Lab production. CO_2 also showed a negative relationship but no significant role can be noticed. Temperature, salinity, water phosphates, organic matter, total nitrogen and available phosphorus showed positive relationship with "Lab-Lab" production at 5% level. Nitrate and phosphates also showed positive relationship but no significant role can be noticed (Figs 15 & 16).

In the CIBA supply canal, rainfall and dissolved oxygen showed a negative relationship with "Lab-Lab" production at 5% level. Temperature, salinity, water phosphates, organic matter, total nitrogen and available phosphorus showed positive relationship with Lab-Lab production at 5% level. In addition to these pH, nitrate and organic carbon also showed a positive relationship but no significant role can be noticed. (Fig. 17 & 18).

Fig. 13 Influence of rainfall, temperature and salinity on Lab-Lab production at Station No. II, Narakkal coconut groves.

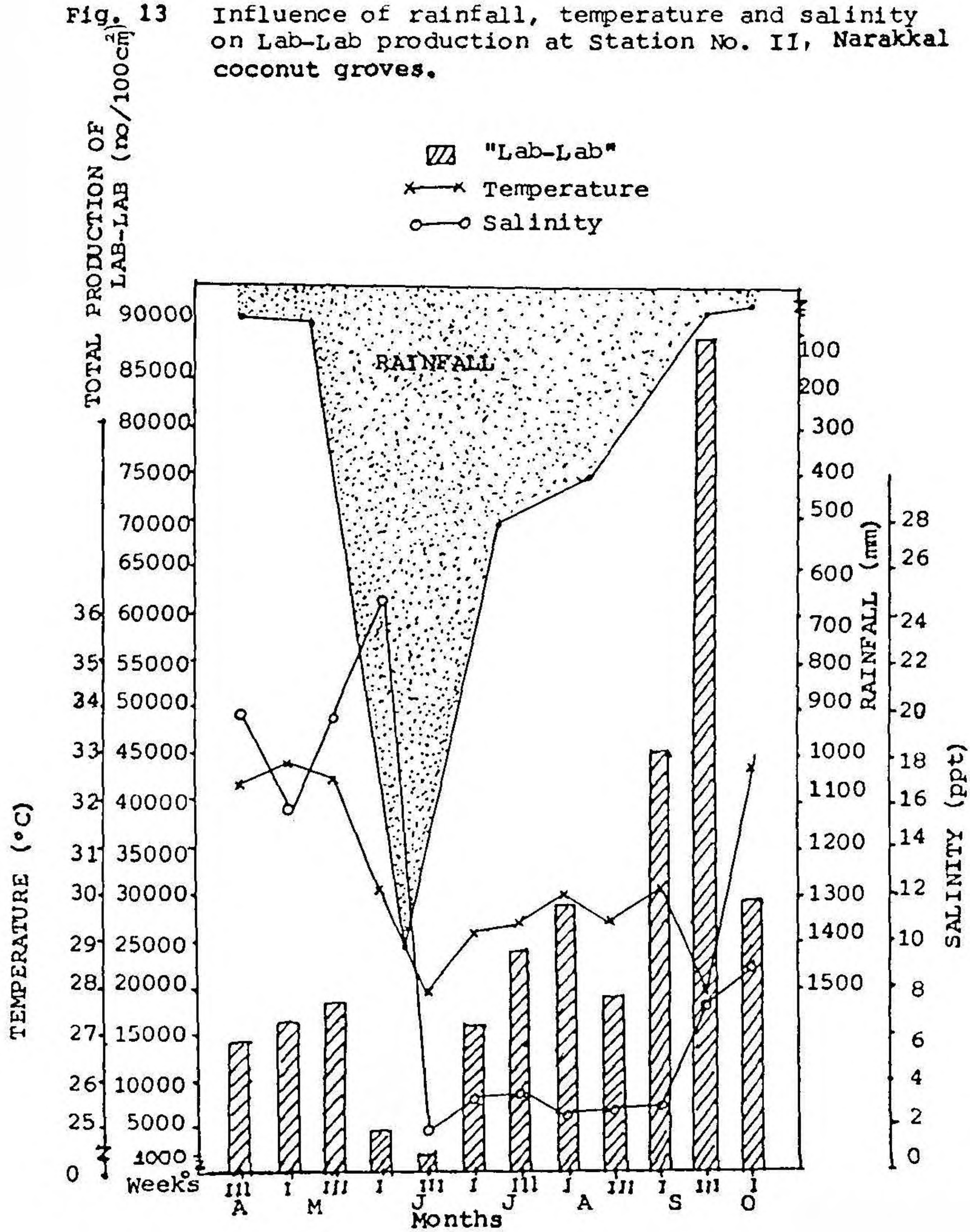


Fig. 14 Influence of sedimentological parameters on the production of "Lab-Lab" at Station No. II, Narakkal coconut groves.

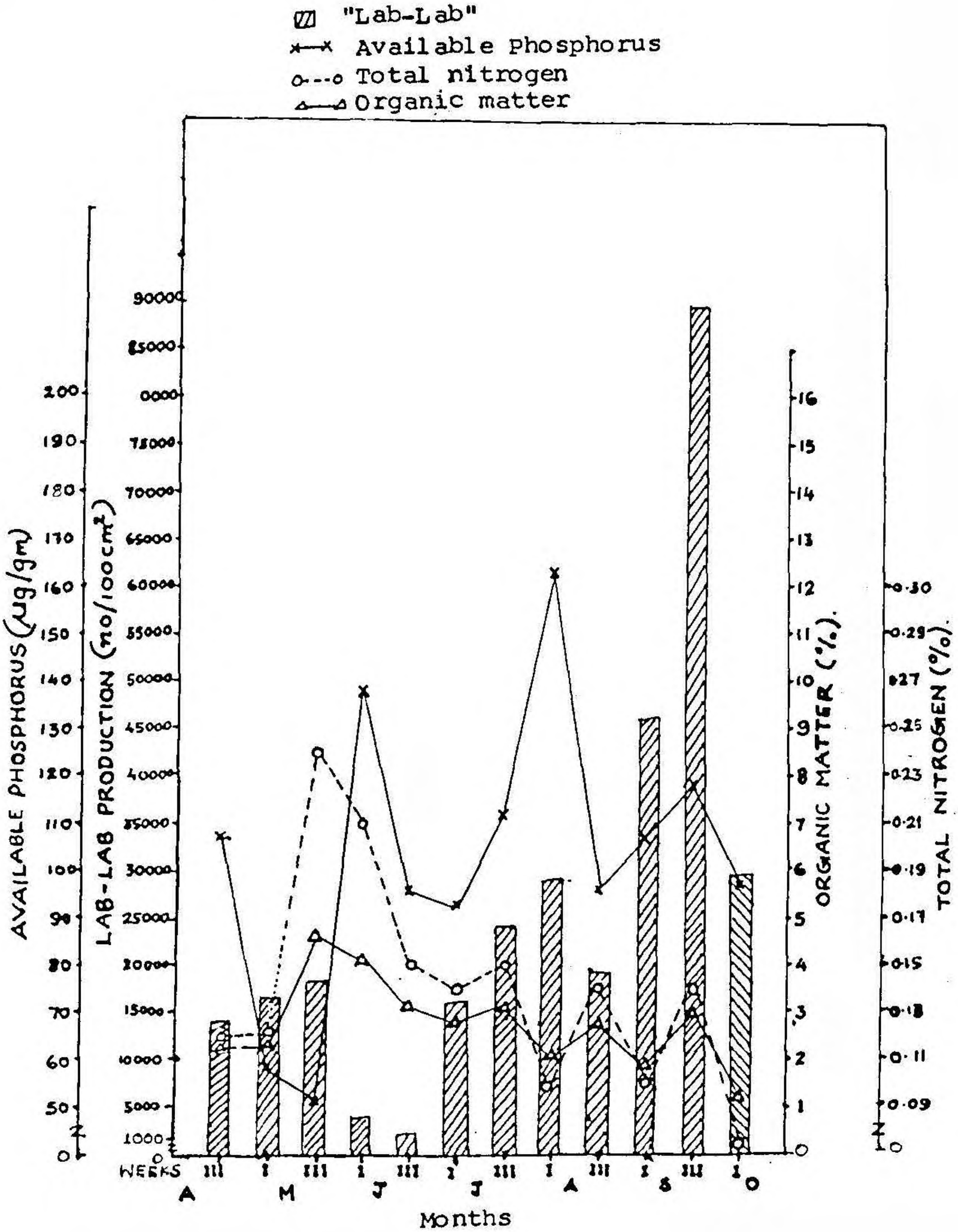


Fig. 15 Influence of rainfall, temperature, and salinity on Lab-Lab production at Station No. III, CIBA experimental pond.

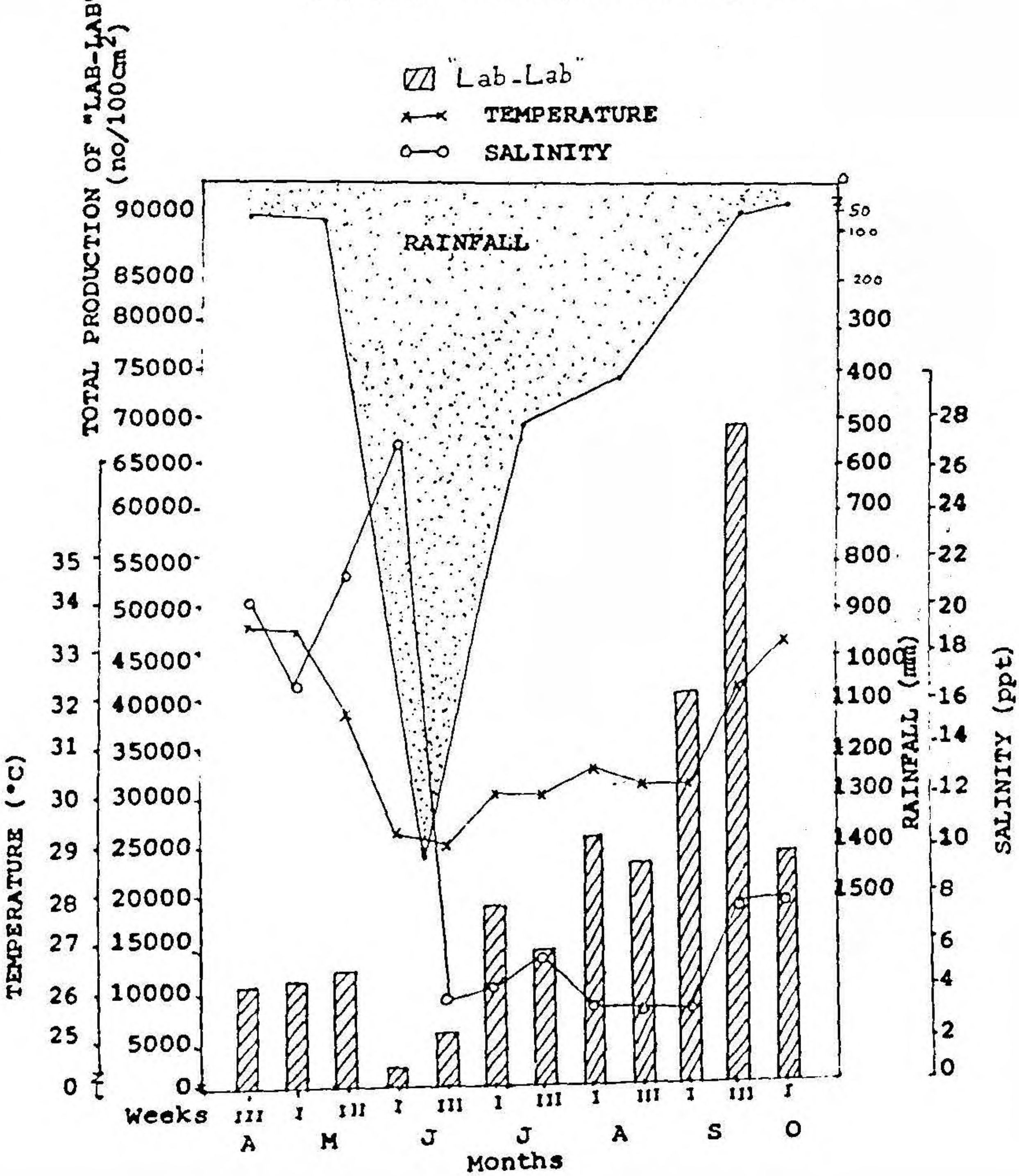


Fig. 16: Influence of sedimentological parameters on the production of "Lab-Lab" at Station No. III, CIBA experimental pond.

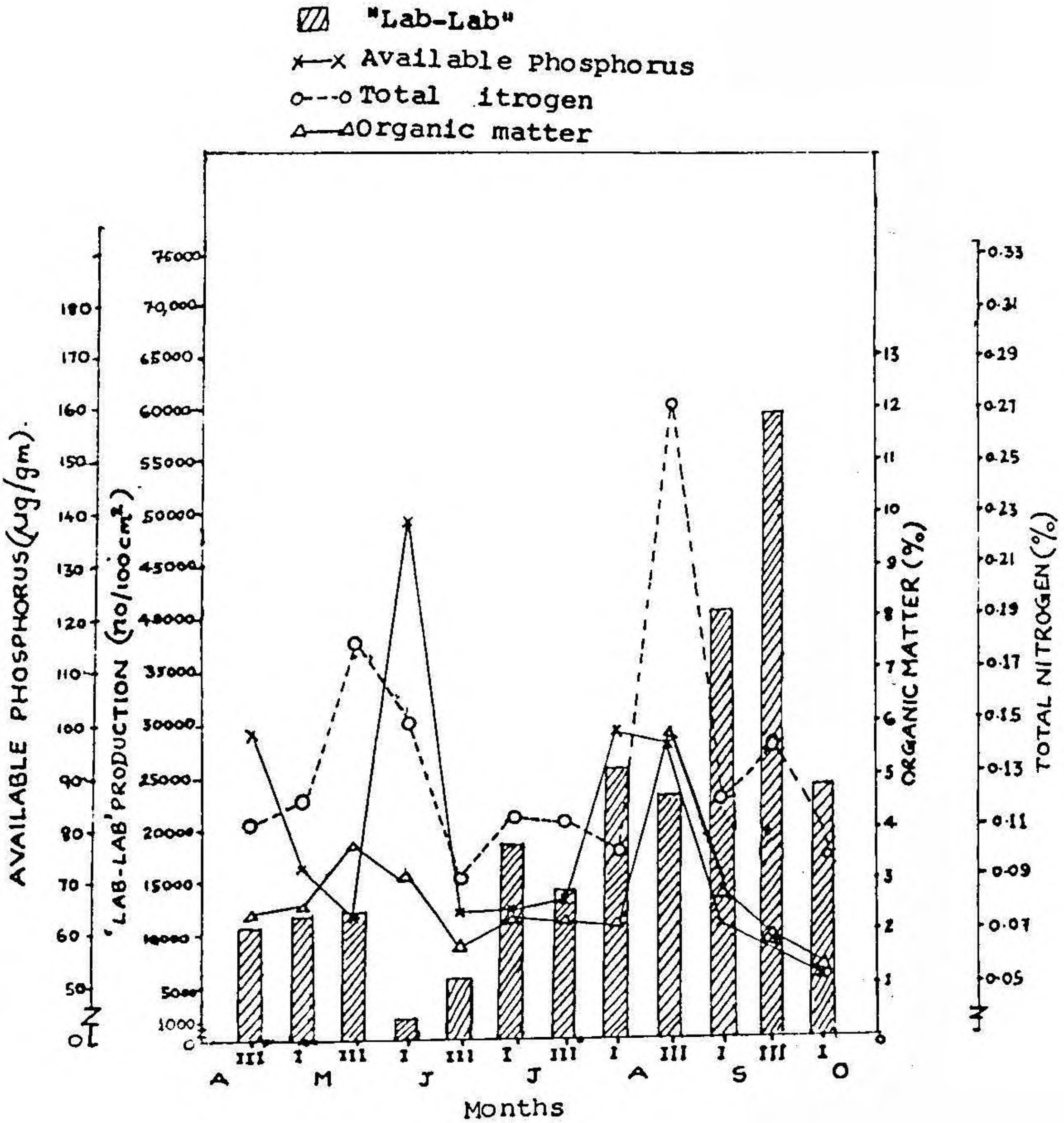


Fig. 17 Influence of rainfall, temperature and salinity on Lab-Lab production at Station No. IV, CIBA Supply canal.

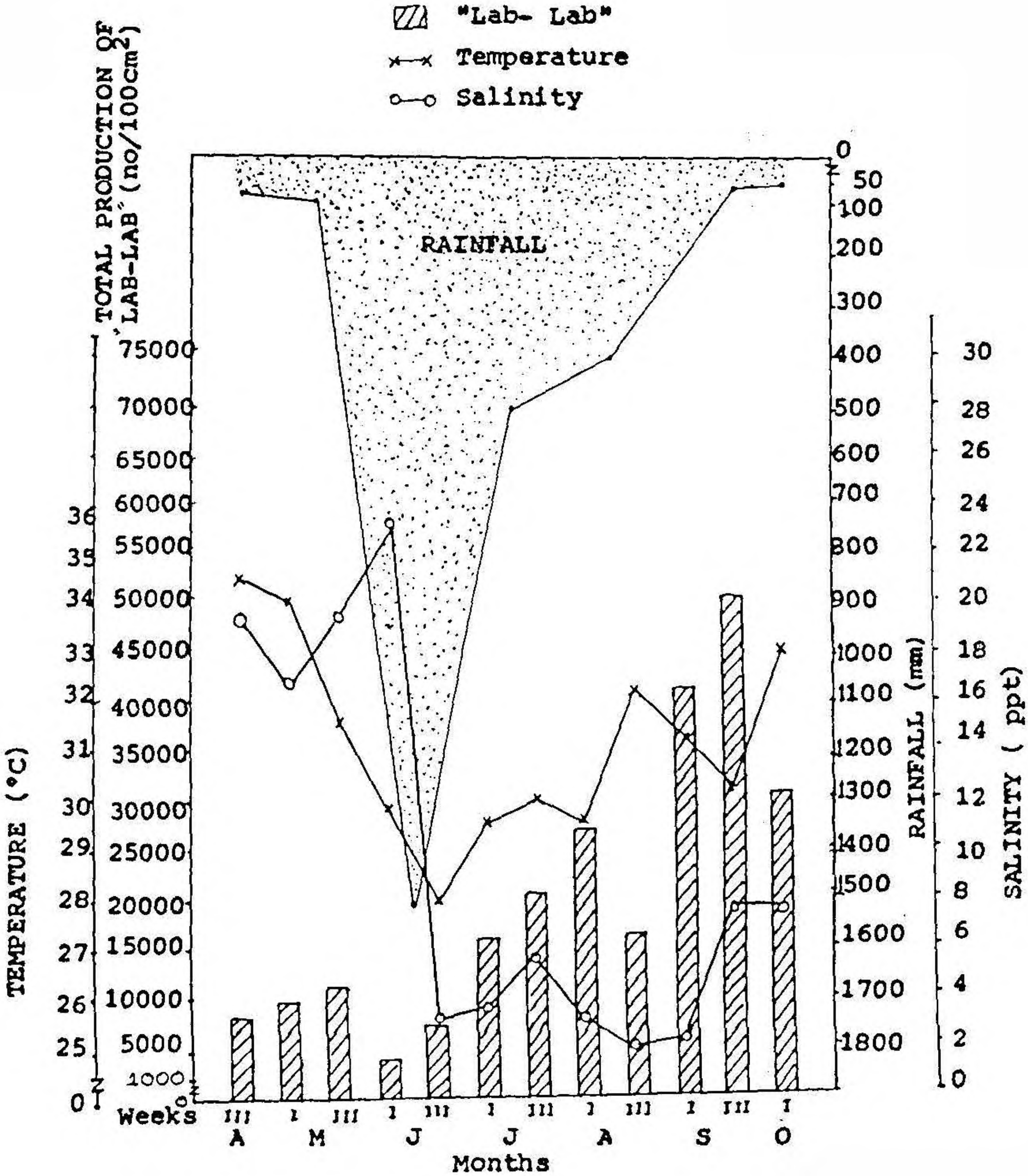


Fig. 18 Influence of sedimentological paramters on the production of "Lab-Lab" at Station No. IV, CIBA supply canal.

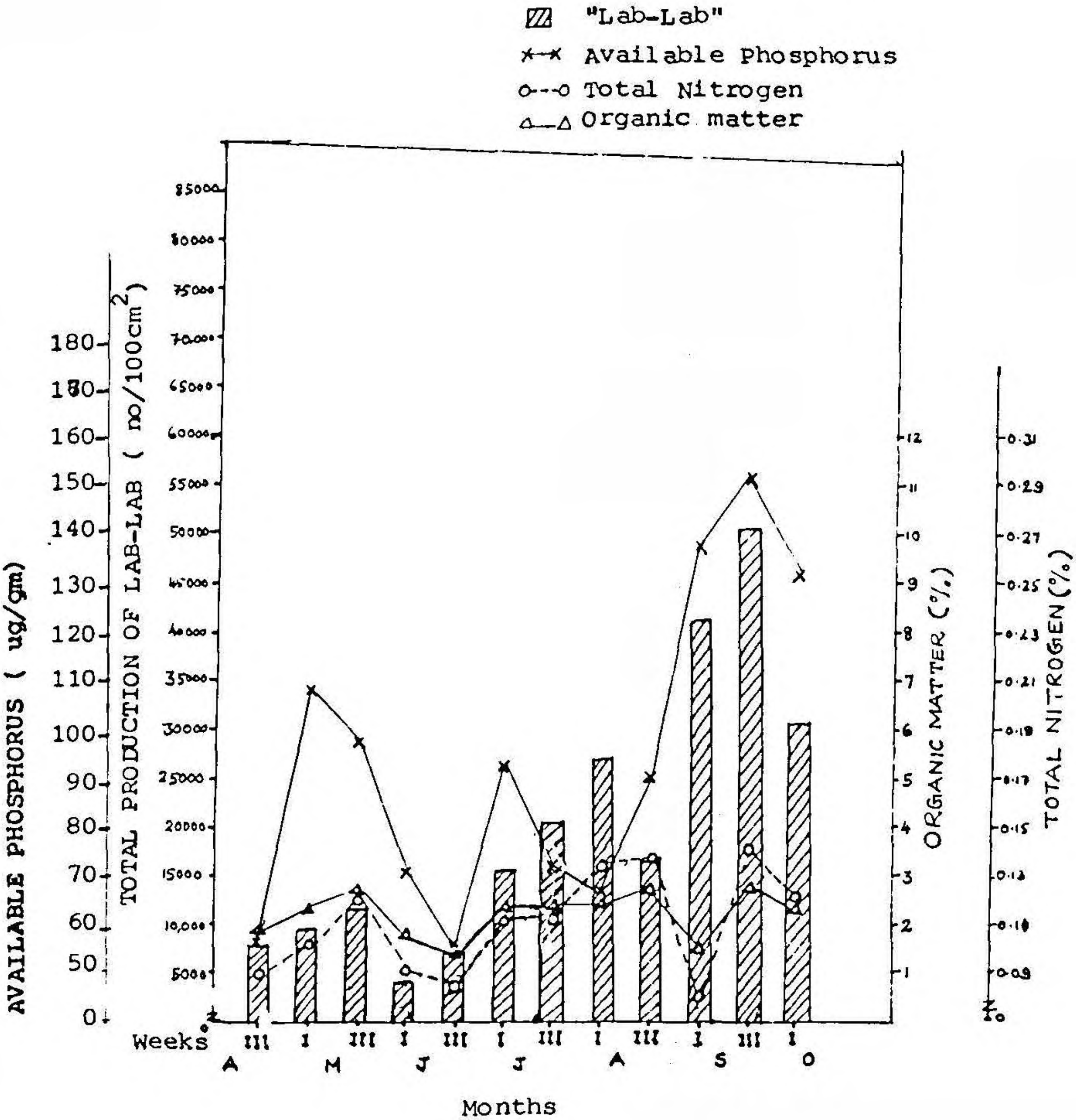


Table: 17

RESULT OF ONE WAY-ANALYSIS

HYDROLOGICAL PARAMETERS: Mean and Standard deviation.

Stations	Water-temperature	pH	Salinity	Dissolved oxygen	Free-CO_2	Nitrate	Phosphate
I. Cherai Pokkali fields	30.012 ±2.25	7.369 ±0.797	10.41 ±10.85	2.43 ±1.21	7.25 ±3.13	0.928 ±0.636	2.688 ±1.8
II. Narakkal coconut-groves	30.394 ±1.80	7.683 ±0.680	9.35 ±8.32	3.53 ±1.6	7.25 ±2.26	1.141 ±1.045	7.302 ±3.5
III. CIBA experimental pond	31.202 ±1.87	7.667 ±0.687	10.07 ±0.849	3.48 ±0.84	7.167 ±3.51	1.00 ±0.93	6.785 ±3.80
IV. CIBA supply canal	31.043 ±2.0	7.554 ±0.71	9.46 ±7.84	2.62 ±0.65	7.75 ±1.9	0.867 ±0.751	6.42 ±3.74

Table:18

RESULTS OF ONE-WAY ANOVA

Hydrological Parameters:

ANOVA

SOURCE	DF	SS	MS	F
Between stations	3	11.168	3.723	0.95
Error	44	172.512	3.921	
Total	47	183.680		

2. pH

SOURCE	DF	SS	MS	F
Between stations	3	0.752	0.251	0.48
Error	44	22.852	0.519	
Total	47	23.604		

3. SALINITY

SOURCE	DF	SS	MS	F
Between stations	3	9.109	3.036	0.04
Error	44	3529.72	80.221	
Total	47	3538.83		

4. DISSOLVED OXYGEN

SOURCE	DF	SS	MS	F	
Between stations	3	11.85	3.95	3.07	Significant at 5% level
Error	44	56.66	1.288		
Total	47	68.52			

Station I and II differ significantly (SE = 0.463).
Station I and III differ significantly (SE = 0.463).

5. FREE-CO_2:

SOURCE	DF	SS	MS	F
Between stations	3	2.56	0.854	0.11
Error	44	342.417	7.782	
Total	47	344.98		

6. NITRATE

SOURCE	DF	SS	MS	F
Between stations	3	0.501	0.167	0.23
Error	44	32.136	0.730	
Total	47	32.637		

6. PHOSPHATE

SOURCE	DF	SS	MS	F
Between stations	3	159.61	53.203	4.76 significant at 5% level
Error	44	491.464	11.170	
Total	47	651.074		

Station I and II differ significantly (SE = 1.364)
Station I and III differ significantly (SE = 1.364)
Station I and IV differ significantly (SE = 1.364)

Table:19

RESULT OF ONE-WAY ANALYSIS

SEDIMENTOLOGICAL PARAMETERS: Mean and Standard Deviation.

Stations	Organic-carbon	Organic matter	Total nitrogen	Available Phosphorus.
1. Cherai Pokkali-fields	2.032 ±0.896	3.45 ±1.45	0.169 ±0.07	88.992 ±31.82
II. Narakkal coconut groves	1.628 ±0.543	2.80 ±0.937	0.139 ±0.048	103.451 ±30.16
III. CIBA experime-ntal pond	1.509 ±0.643	2.59 ±1.1	0.130 ±0.055	78.101 ±23.0
IV. CIBA supply canal	1.309 ±0.244	2.24 ±0.43	0.110 ±0.023	93.62 ±30.69

Table: 20

RESULTS OF ONE-WAY ANALYSIS

SEDIMENTOLOGICAL PARAMETERS

1. ORGANIC CARBON:

ANOVA

SOURCE	DF	SS	MS	F
Between stations	3	3.341	1.114	2.82
Error	44	17.37	0.395	
Total	47	20.71		

2. ORGANIC MATTER:

SOURCE	DF	SS	MS	F	
Between stations	3	9.27	3.090	2.78	Significant at 5% level
Error	44	48.928	1.112		
Total	47	58.198			

Station I and IV differ significantly (SE = 0.431)

3. TOTAL NITROGEN:

SOURCE	DF	SS	MS	F
Between stations	3	0.22	0.007	2.62
Error	44	0.122	0.003	
Total	47	0.144		

4. AVAILABLE PHOSPHORUS:

SOURCE	DF	SS	MS	F
Between stations	3	3987.62	1329.2	
Error	44	37339.96	848.636	1.57
Total	47	41327.59		

Station II and III differ significantly (SE = 11.893)

Table:21

RESULTS OF ONE-WAY ANALYSIS

BIOLOGICAL PARAMETERS:- BLUE GREEN ALGAE DIATOMS AND MICROFAUNA. ("LAB-LAB" CONSTITUENTS)

MEAN AND STANDARD DEVIATION

Stations	Oscillaria spp.	Lyngbya spp.	Phormidium spp.	Sprulina spp.	Pleurosigma spp.	Navicula spp.	Amphora spp.	Netzschia spp.	Coscinodiscus spp.	Copepods	Amphipods	Polychaete warms	Lamellibranch spat
I. Cherai	1658.3	800	2125.0	408.3	4583.3	5440	5766.6	1600.0	420.833	29.58	61.5	30.83	35
Pokkali fields	±2884.59	±932	±2448.7	±869.12	±6029.29	±7073	±5467.4	±1537.4	±735.60	±14.16	±47.9	±13.11	±67
II. Narakkal	6366.67	708.3	2966.6	108.33	5841.66	3958.3	3183.3	1912	450.0	61.667	58.3	59.16	27.5
Coconut greves	±7895.03	±907	±2472.5	±206.52	±3456	±6235.0	±5425.8	±3463.5	±370.5	±29.5	±24.43	±39.41	±38.40
III. CIBA experimental	4558.3	650	3375.0	1233.3	4250	3425.0	3183.33	729.167	262.5	28.75	41.25	36.25	40.00
	±7782.7	±836.1	±3027.7	±1811.2	±5600.08	±3134.0	±3018.98	±723.14	±311.24	±14.16	±12.45	±17.33	±67.5
IV. CIBA supply canal	2175.0	1541.66	2875	883.3	3675.0	1775.0	3925.0	1375.0	325.00	48.75	40.4	40.41	25
	±2064.9	±2181.09	±2367.6	±1306.5	±6330.3	±1538.6	±3800.50	±1489.4	±222.07	±20.35	±21.99	±24.25	±46.0

Table:22

RESULTS OF ONE-WAY ANALYSIS

"LAB-LAB" CONSTITUENTS (BIOLOGICAL PARAMETERS)

1. *Oscillatoria* spp.

ANOVA

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	17209728.0	5736576.0	1.73	N.S.
Error	44	146138776.0	33213358.0		
Total	47	1633485056.0			

Station I and II differ significantly (SE = 2352.7)

2. *Phormidium* spp

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	9775584.0	3258528.0	0.48	N.S.
Error	44	295714016.0	6720773.0		
Total	47	305489600.0			

3. *Lyngbya* Spp.

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	6221664.0	2073888.0	1.16	N.S.
Error	44	78628336.0	1787007.62		
Total	47	84850000.0			

4. Spirulina

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	8955000.0	2985000.0	2.06	N.S.
Error	44	63641664.0	1446401.5		
Total	47	72596664.0			

Station II and III differ significantly (SE = 490.986)

5. Pleurosiqma Spp.

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	30234240.0	10078080.0	0.34	N.S.
Error	44	1317037696.0	29932674.0		
Total	47	1347271936.0			

6. Navicula Spp.

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	33549984.0	11183328.0	0.71	N.S.
Eroor	44	696436352.0	15828099.0		
Total	47	729986304.0			

7. Amphora spp.

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	53517312.0	17839104.0	0.86	N.S.
Eroor	44	911801856.0	20722770.0		
Total	47	965319168.0			

8. <u>Coscinodiscus</u> spp.

SOURCE	DF	SS	MS	F	REMARKS
Between Stations	3	269374.5	89781.5	0.44	N.S.
Eroor	44	9070418.0	206145.85		
Total	47	9339722.0			

9. Copepods

SOURCE	DF	SS	MS	F	REMARKS
Between Stations	3	9143.234	3047.74	7.35	Sig. at 5%
Eroor	44	18252.07	414.82		
Total	47	27395.31			

Stations I and II differ significantly (SE = 8.315)
Stations I and IV differ significantly (SE = 8.315)
Stations II and III differ significantly (SE = 8.315)
Stations III and IV differ significantly (SE = 8.315)

10. Amphipods

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	4434.17	1478.0	1.67	N.S.
Eroor	44	38882.82	883.70		
Total	47	43317.25			

11. Polychaete worms

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	5454.17	1818.0	2.78	Sig. at 5%
Eroor	44	28762.49	653.693		
Total	47	34216.66			

Stations I and II differ significantly (SE = 10.438)
Stations II and III differ significantly (SE = 10.438)

12. Lamellibranch spat

SOURCE	DF	SS	MS	F	REMARKS
Between stations	3	1706.25	568.75	0.18	N.S.
Eroor	44	139425.0	3168.75		
Total	47	141131.25			

Table 23. Result of linear regression analysis between total "Lab-Lab" production and environmental parameters

Station	r value	Rain-fall	Temper-ature	Sali-nity	pH	Dissol-ved oxygen	Free-CO_2	Nitr-ate	Phosph-ate	Organic carbon	Organic matter	Total nitrogen	Availab-le pho-phorus
I. Cherai Pokkali fields	r =	⊖ -0.582	* 0.775	* 0.781	0.381	⊖ -0.729	0.247	0.27	0.087	0.223	* 0.648	* 0.594	* 0.769
		$p < 0.05$	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	p 0.05	p 0.05	p 0.05	p 0.05
II. Narakkal coconut groves	r =	⊖ - 0.69	* 0.0.662	* 0.65	0.44	– 0.45	0.026	0.572	* 0.727	0.404	* 0.578	0.584	* 0.720
		$p < 0.05$	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$	p 0.05	p 0.05	p 0.05	p 0.05
III. CIBA experi-mental pond	r =	⊖ -0.580	* 0.578	* 0.579	* 0.673	– 0.144	0.116	0.332	0.523	0.14	* 0.580	* 0.66	* 0.589
		$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	p 0.05	p 0.05	p 0.05	p 0.05
IV. CIBA supply canal	r =	⊖ -0.589	* 0.587	* 0.578	0.518	⊖ - 0.638	0.571	0.337	* 0.710	0.408	* 0.632	* 0.583	* 0.775
		$p < 0.05$	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$	p 0.05	p 0.05	p 0.05	p 0.05	p 0.05

⊖ Significant (relationship is negative)

* Significant (relationship is positive)

D I S C U S S I O N

The culture ponds, the pokkali fields and the canal systems studied are mostly extensions of the estuarine and backwater masses and therefore are subjected to wide variations in their environmental conditions. These are dynamic ones, in which monsoon rains leads to changes in the hydrobiological conditions from those prevailing during the premonsoon season to the almost freshwater condition during the monsoon period. Thereafter, there has been a gradual but progressive recovery of the saline condition during the postmonsoon months. It has been established that abiotic factors, particularly chemical characteristics of the environment exert profound influence on the growth and survival of aquatic organisms such as algae and the microfauna. Hence, in the present study, attention has been given to elucidate the nature and extent of the physical, chemical and environmental features and their bearing on the productivity of "Lab-Lab" in the four selected ecosystem viz., the seasonal paddy-cum prawn culture fields at Cherai, coconut groves at Narakkal, the CIBA experimental pond and the CIBA supply canal during April - October 1991.

The temperature regime of Cochin backwater system generally within a narrow range has been found to be influenced by various factors like rainfall and freshwater influx (Gopinathan, 1972; Kumaran and Rao, 1975), Solar radiation (Sankaranarayanan and Qasim 1969; Silas and Pillai, 1975) and the flow of underwater currents. Although the causative factors are many, a general distributional pattern of high values during premonsoon and postmonsoon seasons and a lowering of the values during south west monsoon season had been established in Cochin backwaters. (Gopinathan, 1972; Kumaran and Rao, 1975; Pillai et al., 1975; Silas and Pillai, 1975). In the present investigations, the temperature pattern during the different seasons has been in agreement with the earlier observation; where the values were as high as 33.25°C in Station I, 32.65°C in Station II, 34.5°C in Station III and 34°C in Station IV during the premonsoon (May), followed by an abrupt decrease during the monsoon and reaching minimum values of 26.5, 27.95, 29.0, 28.0°C in the Stations I, II, III and IV respectively in the III week of June. From these it can be concluded that the fluctuations in temperature in all the Stations are mainly due to the freshwater influx. According to Tang and Chen (1967) temperatures ranging from 25°C to 33°C is suitable for "Lab-Lab" growth. This agrees with the present investigation. In the present study also a positive relationship seems to exist between "Lab-Lab" production and temperature.

Among the various environmental parameters, salinity is found to have significant influence on the existance of flors and fauna in an estuarine sustem (Haridas *et al.*, 1973). The variation of salinity are very wide because of the differential influence of the tides and of the heavy freshwater drainage during the monsoon. (George and Krishnakartha, 1963). Earlier observation in Cochin backwater have shown that the surface salinity remains high during the premonsoon and that it is reduced greatly with the onset of the monsoon (Kumaran and Rao, 1975; Pillai *et al.*, 1975). In the present study also during the pre-monsoon season, salinity of all the stations was higher than during the monsoon season which may be due to the influence of tide and lesser influence of freshwater run off. But with the onset of monsoon, the values were found to decrease drastically and this may be attributed to the influence of freshwater run off and land drainage. Wide fluctuations of salinity observed among the stations, indicates the influence of their proximity to freshwater or marine environment. Salinity was found showing a decreasing trend with the increase in distance from the bar mouth. The extent of intrusion of saline water depends on the strength of tidal influx and freshwater flow which differs with seasons. In the present investigations, all the four stations showed high salinities during premonsoon: 27 ppt in Station I, 24.66 ppt in Station II, 24.47 ppt in Station III and 23.3 ppt in Station IV, thereby confirming the influence of seawater and less mixing with freshwater. Similarly in all the stations from June III week onwards low salinity range was observed and the water was almost fresh, obviously due to the freshwater run off and least tidal influence. According to Tang and Chen (1967), salinity between 10 and 25 ppt is suitable for "Lab-Lab" growth and salinity below 5 ppt destroys the growth of algal pasture in Taiwan. In the present investigation, the salinity showed a positive relationship with the "Lab-Lab" production.

Dissolved oxygen in water is vital for all living beings, and it plays a very important role in aquatic life. Variations in dissolved oxygen concentration in Cochin backwater in terms of time and space were studied by several workers (Haridas et al., 1973; Kumaran and Rao, 1975; Pillai et al., 1975; Silas and Pillai, 1975). According to them, dissolved oxygen content was high during the monsoon than during premonsoon season, probably due to precipitation. In the present study also highest concentration of dissolved oxygen was observed during monsoon season in all the four stations.

The pH of water showed considerable fluctuations in time and space. Earlier observations in Cochin backwaters (Sankaranarayanan and Qasim, 1969; Silas and Pillai, 1975) and in Ashtamudi Estuary (Nair et. al., 1983) showed that maximum pH in these waters observed during premonsoon season was mainly due to the influence of seawater of high pH, and the minimum range during monsoon season was due to the influence of freshwater. In the present investigation also, it may be seen that higher pH values prevailed during the premonsoon season in all the four stations, with low values during the monsoon season. According to Tang and Chen, (1967) the pH value ranging from 8.0 to 9.5 is considered to be the optimum for growth of "Lab-Lab" in Taiwan. The pH also showed a positive relationship with the "Lab-Lab" production.

The free carbondixoide ranged between 4 mg/l and 17 mg/l in all the stations. The higher concentration was noticed in premonsoon period in all the stations. The CO_2 level showed a positive relationship with the 'Lab-Lab' production.

The distribution of nutrients in prawn culture pond has been studied earlier, by Sankaranarayanan et al. (1982) and Gopinathan et.al. (1982). During the present study concentration of nutrients in different pond was investigated.

Inorganic phosphate in the waters showed relatively high values above 2 µg at/l in most of the months and the monsoon season in all the stations. But, high values of inorganic phosphate were also recorded in the postmonsoon season in all the stations. George and Krishnakartha, (1963) and Qasim Wyatt (1973) have reported the months of June and July as the period of higher phosphate concentration in the estuary. The phosphate levels showed a general increase during the south west monsoon period in prawn culture fields (Sankaranarayanan et al., 1982). The result obtained during the present study agree with the above conclusion. In Cherai pokkali fields, the values ranged between 1.1 and 7.13 µg at/l in the monsoon period with the peak of 7.13 µg at/l in the first week of July. In the Narakkal coconut grove, the concentration was between 2.15 and 14.75 µg at/l in the monsoon period with the peak of 14.75 µg at/l in the third week of July. In the CIBA experimental pond, the range was between 2.15 and 12.4 µg at/l in the monsoon period with the maximum in the third week of July. In the CIBA supply canal, the values ranged between 1.8 and 12.08 µg at/l with the highest value of 12.08 µg at/l in the third week of July. The high values of phosphate in the water would be attributed to the use of fertilizers in the fields/ponds and the leaching out activity during the monsoon months. The phosphate showed a positive relationship with the "Lab-Lab" production.

Nitrate concentration has ranged widely in the four ecosystems during the period of the present study with high values during monsoon period. These results are very much similar to those observed for the nitrate distribution in the culture ponds; and agree with those observed in the prawn culture fields by Gopinathan _et al_., (1982) and Sankaranarayanan _et al_., (1982). A similar observation was also made in Ashtamudi estuary by Nair _et al_., (1983) and Nair and Abdul Azis (1987). In the present investigation, the high level of nitrate during monsoon attributed to the land drainage and fresh water run off (Sankaranarayanan and Qasim, 1969). Nitrate also showed positive relationship with "Lab-Lab" production

Qasim and Sankaranarayanan have studied the organic detritus of Cochin backwaters. They listed the source of detritus as plankton, large quantities of benthic algae, rooted plants, animal matter, suspended soft mud and the material brought down by the rivers and the land run off. They observed little change in the detrital carbon, phosphorus and nitrogen. According to them the caloric values of detritus calculated from protein, carbohydrate, lipid and organic carbon have indicated that the sedimental detritus does not have a high nutritional value. However in their opinion, being a readily available material its entry into the food chain seems to increase the efficiency of energy transfer from one trophic level to another.

Sankaranarayanan _et al_., (1979) have studied the organic carbon phosphorus and nitrogen in sediment of Cochin backwater. They observed high organic carbon content and opined that it may be attributed to river with a high amount of water humus.; and high organic production of the over lying water. Nagarajaiah and Gupta (1983) have recorded high organic carbon in the brackishwater ponds along Nethravali Estuary during the monsoon, and felt that such a high concentration would be due to the decaying planktonic organisms killed as a result of the sudden drop in the salinity there and settling to the bottom along with carbonacious materials brought in by the river.

Ansari and Rajagopal (1974) have studied the distribution of total, absorbed and intestitial phosphate in the mud of Cochin backwaters and reported wide variations in the concentration of the total phosphate which was higher during the southwest monsoon months than the other seasons. Further, they noted that the phosphate content of the sediment of silt and clay was higher than that of coarse sandy sediments. A similar condition is observed in all the four stations in the present study and the phosphate concentration is higher in Cherai Pokkali fields where the texture of the soil is clayey. The higher level of phosphate concentration in monsoon period may probably be related to the influence of land drainage and freshwater flow into the system.

As the available phosphorus promotes growth of algal pasture, the application of either organic or inorganic phosphate to the bottom soil is essential. According to Tang and Chen (1967) high level of phosphorus promot "Lab-Lab" production. In the present study the total production showed positive relationship with the available phosphorus.

Total nitrogen values varying between 0.09 and 0.29% in all the stations are more or less uniform. The same pattern was also observed in Cochin backwater by Sankaranarayanan and Qasim, (1979). According to Tang and Chen (1966), higher total nitrogen content produces higher yields of algal pasture. In the present study also a positive relationship seems to exist between "Lab-Lab" production and total nitrogen.

Nature of the substratum may be an important factor restricting the abundance of microfauna present theirin. Panikar Aiyer (1937) have observed the absence of animals in substrate of thick clay and their greater abundance in a loose substratum. Desai and Krishnankutty (1967, 1969) have observed that medium sand and small amount of silt and clay are suited for the abundance of polychaete worms and bivalves. A definite relationship between the nature of substratum and the distribution of the benthic fauna theirin has been reported by Kurian (1969), Sanders (1958), Parulekar et al., (1975) and Murugan et al., (1980). Harkantra (1980) has observed the abundance of benthos in sandy clay sediment followed by silty sand sediment. Clay can support a very poor benthic microfauna indicating that the median particle size harbours more population than the fine particle size. Kurian (1967) has observed that sandy deposits have high values of the benthos at some places, while at others the production is low in similar deposits. These suggest that the type of the substratum may not be considered indipendently as a master ecological factor to determine the distribution and abundance of microfauna in it.

In the present study it has been observed that the sediment type has an influence on the abundance and distribution of fauna and flora present in it. In Cherai Pokkali field, the nature of the substratum is clayey and the abundance of fauna and flora are observed to be poor, which agrees with the observation of Panikar and Aiyer (1937), who have reported the absence of organisms in substrata of thick clay. In Narakkal coconut groves, the CIBA experimental pond, and the CIBA supply canal, the substrata are found to be sandy in nature supporting microfauna therein. This agrees with the observation of the earlier workers, Desai, Krishnankutty (1967, 1969) and Harkantra (1980).

According to Dajajiredja and Poernomo (1972) the best soil for "Lab-Lab" growth is silty loam, Tang and Chen (1967) suggested that silty loam and loamy soil are most favourable for growing algal pasture. Frey (1947) has observed that "Lab-Lab" growth is greater when the bottom mud is peaty clay than other kinds of soil.

Kurian *et al.*,(1975) have felt that the abundance of polychaetes, bivalves and crustacean in the fine sediment is mainly due to the higher organic matter present, which serves as the food material.

Among the four ecosystems, the pokkali field at Cherai, with its high content of organic matter and clayey texture of sediment was found to be the least populated. Higher population density of microfauna was observed in the coconut groves and in the CIBA experimental pond where the organic matter content and percentage of clay in the sediment was found to be relatively lower. This agrees with the findings of Ansari *et al.*, (1977), who have observed that microfaunal components occured in greater abundance in sandy sediments which contained a little amount of silt and clay, than in clayey sediments and coralline sand. In the present study, copepods showed a positive relationship with organic matter at Cherai pokkai fields and the CIBA supply canal.

Thus apart from the above mentioned factors, another important factor in the distribution of bottom fauna is the food supply therein. Hence the presence of detritus plays an important role in the abundance and distribution of microbenthic fauna.

The importance of defritus as food for benthic fauna including meiofauna was been established by Darnell (1967), Finenko and Zaika (1970) and Sorokin (1976). Detritus harbours not only bacteria, but also protozoans which form 'microcosms' around and within the detritus particle (Fenchel, 1970). Tenore et al., (1977), Sikora et al., (1977) and Reipef (1978) have explained that meiofauna ingest detritus and the attached micro organisms. Sorokin, (1981) has observed that microbial biomass is a principal nutritional component in sediments and play a role in the regulation of microfaunal population. Bell and Coul (1978) have attributed the productivity of meiofauna to the existence of microbenthos, emphasising their role as food to the meiofauna. But the presence of adequate number of micro organisms should decompose and deplete the organic carbon of the sediment. Accumulation of organic matter can also be attributed to the lack of utilization of the same by benthic detritivorus organisms that would otherwise utilize the organic matter and convert it into utilizable matter for the microbial biomass (Rodina, 1963; Briggs et al., 1979).

Murthy and Veerayya (1972) have stated that in the sediments of the Vembanad Lake, a relationship existed between organic matter and grain size of the mud. According to them and Russel (1950) more organic matter is present in the substratum containing mostly clayey soil, than in the substratum containing fine silt, course silt and sand; and that maximum organic matter is present in sediments with high clay content.

Gopinathan <u>et</u> <u>al</u>., (1982) also reported high organic content in the sediment of Pokkali fields and attributed to the decay of roots and stumps of the paddy left to rot after the harvest. The present study supports the above observation; and it has been seen that the clayey sediment in the pokkali field retains more organic matter when compared with the sediments in the canals of the coconut grove, the CIBA experimental pond and the CIBA supply canal.

According to Tang and Chen (1967), higher organic matter content contributes to a better growth of algal pasture. Since the growth of "Lab-Lab" particularly the blue-green algae requires much organic matter in the soil, pond bottom which are rich in organic matter are indicative of high productivity.

The relationship between the distribution and abundance of benthos and the percentage of organic carbon have been studied by many workers like Bader (1954), Sandars (1958), and Kurian (1969). They have suggested that high productivity of benthos in the estuary may be due to high percentage of organic content there. Varshney (1970) reported that the percentage of organic matter and the faunal density showed no direct relationship. Bader (1954), while studying the abundance of bivalves in relation to the percentage of organic carbon, has observed a decrease in the bivalve population when the organic carbon is above 3%. He points out that beyond this concentration, products of bacterial decomposition and decline in the available Oxygen becomes a limiting factor. Harkantra (1980) has observed a decrease in the benthic animals when the organic content is high. It appears that the organic carbon is one of the limiting factors, controlling distribution and abundance of benthic populations. In the present study organic carbon has been high in all the ecosystem, but not more than 3% except in pokkali field during May and June.

According to Tang and Chen (1967) the production of "Lab-Lab" during monsoon season is low. In the present study also the production of it has been less in the monsoon period. This may be attributed to the water flowing out of the pond due to the rains and the resultant loss of plant nutrients and a decrease in soil fertility.

The major "Lab-Lab" constituents observed are the cyanophyceae: *Oscillatoria* spp, *Lyngbya* spp, *Phormidium* spp *Spirulina* spp; the Bacillariophyceae such as *Navicula* spp, *Pleurosigma* spp *Amphora* spp, *Nitzschia* spp and the microfauna such as Copepods, Amphipods, Polychaete worms and Lamelli branch spat. The same was also observed by Tang and Chen (1966) at Taiwan.

The distribution and abundance of phytoplankton in Cochin backwater and in other estuaries were extensively studied by several workers. The results obtained by Gopinathan (1972) and Santhanam *et al*., (1975) has shown that the abundance of algal complex and diatoms is maximum during the early monsoon and monsoon period. However the observations by Joseph and Pillai (1975), Kumaran and Rao (1975) and Gopinathan (1981) in Cochin backwater and Ramdhas (1977) in Vellar estuary have indicated that the abundance of phytoplankton has reached its maximum concentration during the pre-monsoon, while minimum concentration has been recorded during the monsoon season. In the present study a peak season of phytoplankton has been observed during the premonsoon at Kochi i.e., in the month of May and minimum during the monsoon in all the four stations. In all these stations the number of phytoplankters has been found to be increasing again during the postmonsoon period and has reached the maximum in September forming a secondary peak as has also been noticed by Gopinathan (1972). Gopinathan *et al*., (1984) have observed two seasonal peaks of phytoplankton production, a primary one during the premonsoon and a secondary one during the post monsoon in the Kochi backwaters. In the present study also such a situation has been observed during the period of study from 1991 April to October 1991. High productivity has been recorded with the influx of inshore water into the culture ponds. It has also been observed that the low rate of production is due to the low replenishment of nutrients by water or by the influx of freshwater. The present study substantiate the earlier observations that the culture pond located at Narakkal in between Kochi and Azhikode barmonth are relatively a more productive ecosystem (George _et al_., 1968; and George 1974) than the others. The advantage of the presence of two openings through which there is a regular incursion of saline water and also periodical enrichment of the nutrients by the run off from Periyar River and the related seasonality may be a causative factor for the high rate of production. However the high rate phytoplankton production in the Cherai pokkali fields during the premonsoon may be due to a very low level of water depth (18 cm) as observed in the culture ponds. The observed seasonal phytoplankton production in the culture ponds agree with the observations made by Gopinathan _et al_., (1984)

The marine forms of phytoplankton _viz_., _Plenrosigma_ spp, _Navicula_. spp _Amphora_ spp, _Nitzschia_ spp and _Coscinodiscus_ spp have been dominant throughout the study period except in June in all the four stations. In the month of August and September, the production of these are very much high. The same has been observed by Gopalakrishnan _et al_., (1988) in paddy-cum-prawn culture fields in and around Kochi. The predominance of _Coscinodiscus_ spp throughout the study period in all the different systems brings out the tolerance of this group to higher salinity variation as also noted by Joseph and Pillai (1975). A succession of blooms of _Conscinodiscus_ has been noticed in Kochi backwaters in the salinity range of 0-25 ppt by Qasim, Bhattathiri and Devasi (1972).

During the monsoon season, the brackishwater and /or fresh water forms such as Oscillatoria spp Phornidium spp, Lyngbya spp and Spirulina spp contributed to a larger percentage of the total microflora production in all the four stations. This may be due to a reduction in the salinity caused by the flow of fresh water to a considerable extent, as also noted earlier by Joseph and Pillai (1975). The production of Oscillatoria spp, Phormidium spp and Lyngbya spp has gradually increased from the month of July and has attained a peak in September at all the four stations. The significant occurance of this group agrees with the findings of Gopalakrishnan et al. (1988) in the paddy-cum-prawn culture fields at Kochi.

The seasonal and spatial fluctuations of the microfauna during the present investigations are reflective of the hydrological and sedimentological. Characters of the ecosystems. During the premonsoon period, the rainfall has been negligible and the salinities at all the stations are significantly higher than during the other periods. Temperature also has remained higher during this period and this condition has continued to be so until the onset of the monsoon. The number of microfauna has been significantly higher during this period when the above conditions prevailed than during the other periods. But, the number of microfauna has greatly declined during the monsoon period when the salinity of the water has decreased to a considerable level with a corresponding decline in the temperature. A similar fluctuation in the abundance of microfauna with a maximum during the premonsoon and a minimum during the monsoon period has also been observed by several workers earlier, viz., Menon et al., (1971), Nair and Tranter (1971), Kumaran and Rao (1975), Pillai et al., (1975), Silas and Pillai (1975), and Madhupratap et al., (1977) in Kochi backwater.

The microfauna as a "Lab-Lab" constituent has been dominated by Copepods, Amphipods, and polychaete worms in all the culture systems.A similar dominance has been observed by Gopalakrishnan et al., (1988) in the paddy-cum prawn culture fields at Kochi. This is also said to be a reason for the successful prawn fishery in this area as observed by Gopalakrishnan et al., (1988).

The role of nutrients and their seasonal variation in Kochi backwaters have been studied earlier by Sankaranarayanan and Qasim (1969). They have observed that the first peak of phytoplankton abundance during May appears to coincide with the higher concentration of phosphate and nitrate in the estuary. The phosphate and nitrate values after attaining their primary peaks during the period of May to June I week, have attained a secondary peak during postmonsoon in Kochi backwater as observed earlier by Sankaranarayanan & Qasim (1969). The secondary peak in microflora production has also noticed in all the stations coincides with this period.

The "Lab-Lab" production is directly related to the nutrient status of the soil. (Pillai et al., 1972). In the present study the total production of "Lab-Lab" showed positive relationship with soil organic carbon, organic matter, available phosphorus and total nitrogen, in all the stations. According to Tang and Chen (1967) high level of these soil nutrients is essential for the growth of "Lab-Lab".

Copepods showed a positive relationship with dissolved oxygen in Station I. Dissolved oxygen in water is vital for living organisms, both animal and plant; and it plays a crucial and vial role in aquatic life. In the present study, such a relationship exists between the production of copepods and dissolved oxygen content. This agrees with the findings of Haridas et al., (1973), Kumaran and Rao (1975), Pillai et al., (1975), Silas and Pillai (1975) and others.

As observed earlier, in Cherai Pokkali fields, the organic matter appears to have an influencing role in the production of polycheate worms. In Cherai pokkali fields and the CIBA supply canal, the production of copepods showed a positive relationship with organic matter. Thus, organic matter plays an important role in the abundance and distribution of organisms. The importance of organic matter as food for benthic fauna including micro and meiofauna has already been established by Darnel (1967), Finenko and Zaika (1970) and Sorokin (1976).

The copepods showed a positive relationship with water phosphate in Cherai pokkali fields and Narakkal coconut groves. The abundance of polychaete worms appear to be directly related to soil phosphate in the CIBA experimental pond. Studies on the phosphorus cycle in the Indian waters have been carried out by some workers. From the West Coast the important investigations carried out earlier are those of Bal et al., (1948), George (1953), Seshappa and Jayaraman (1956), Rao (1957), Subramanian (1959), Jayaraman and Seshappa (1957) and Damodaran (1973). Jayaraman (1954), Ganapthi et al., (1956), Thirupad and Reddy (1959), Viswanathan (1959) and Ramamurthi et al., (1965), Krishnamurthi (1966) has made observations on the phosphorus cycle in the inshore waters of the east coast of India. Recently Gopinathan et al., (1982) have studied the distribution of inorganic phosphorus in the culture fields adjacent to the Kochi backwater system. However, very little attempt has been made to correlate the benthic fauna with the available phosphorus in the sediments, from the culture systems in the areas of study.

Harvey (1950) and Armstrong and Harvey (1950) gave evidence that phosphorus concentrations of the ambient water might act as a limiting factor in microfauna production in the English channel and the sea of plymouth. However, investigations by Raymont (1950) on the benthos of Kyle Scotnish have shown that the phosphate concentration does not affect the benthos. Jones (1956) based on his studies from the faunal deposits of Port Erin has reported that while the temperature, salinity and substratum remains stable, biomass of benthos could be directly correlated to the concentration of phosphorus in the overlying water.

From the foregoing discussion it may be seen that the distribution and abundance of "Lab-Lab" constituents are influenced by various hydrological and sedimentological parameters. Thus the study enables us to have some insight into the available "Lab-Lab" constituents in the culture system in and around Kochi and the influence of ecological parameters on their production. However, since the study and observations have been rostricted to a limited period of only six months and covering only a few stations, a firm conclusion interms of time and space could not be drawn. Therefore, it is suggested that further steps may be taken to implement a detailed study on these lines in Kochi and the entire estuarine systems of the country at large, for envisaging a full fledged brackishwater culture industry for such herbivorous fishes as Chanos and mullets.

SUMMARY

"Lab-Lab" constituents and the prevailing environmental parameters in four brackishwater culture systems i.e., a paddy-cum prawn culture field ("Pokkali") at Cherai, a coconut grove at Narakkal, an experimental pond of the Central Institute of Brackishwater Aquaculture (CIBA) and the Supply Canal for the above pond were studied from April 1991 to October 1991.

This study was undertaken for finding out the different constituents of "Lab-Lab" present in these systems, their abundance during different seasons and their relationship if any to the hydrological and sedimentological parameters in each locality.

Fortnightly hydrological parameters of water depth, turbidity, pH, salinity, dissolved oxygen, free carbondioxide, phosphate, nitrate were observed and recorded from these stations.

The variations in temperature was 26.5°C - 34.63°C and pH 5.64 - 8.25 in these stations. Salinity showed drastic changes of 0.63 - 27 ppt in all the systems. The free carbondioxide content was between 4 mg/l and 17 mg/l and the dissolved oxygen was between 1.01 ml/l and 6.74 ml/l. The nitrate values ranged from 0.10 µg at/l. to 2.79 µg at/l. The phosphates showed fluctuations between 1.1 µg at/l and 14.75 µg at/l. In the month of May, the salinity and temperature

attained their peaks and during June after the onset of South west monsoon, their values have decreased considerably. Dissolved oxygen, water nutrients, phosphate and nitrate values showed an increasing trend during the monsoon period.

The sedimentological parameters studied were percentage organic carbon, organic matter, total nitrogen, available phosphorus and the grain size of sand particles in the substratum. The organic carbon has varied between 0.9% and 3.48% and the organic matter between 1.55% and 5.99%. Higher values of organic carbon and organic matter were observed in Cherai pokkali fields throughout the period of study than in the other stations. The percentage of total nitrogen has ranged between 0.09 and 0.29% in all the stations. The concentration of available phosphorus was from 38 µg/gm to 134.44 µg/gm. The texture of the sediment in Cherai pokkali field was clayey but in Narakkal coconut groves, the CIBA experimental pond and the CIBA supply canal , this was sandy in nature.

The "Lab-Lab" present in the substrata in these stations was composed mainly of blue green algae - Oscillatoria spp Phormidium spp, Lyngbya spp, Spirulina spp; the diatoms - Pleurosigma spp, Navicula spp, Amphora spp, Nitzschia spp and Coscinodiscus spp; and the microfauna - Copepods, Amphipods, Polychaete worms and Lamellibranch spat. All these were studied for biomass calculations.

The "Lab-Lab" production in Narakkal coconut groves was relatively higher compared to the other systems, followed by Cherai pokkali field and the CIBA experimental pond. The production was poor in the CIBA supply canal.

The total production of "Lab-Lab" has drastically declined in June, obviously due to the onset of South West monsoon rains in all the four stations. A good production of "Lab-Lab" was observed during May and September in all the four stations.

From the results of the present investigations the following relationships are found out from hydrological, sedimentological and biological parameters:

- Spirulina spp is positively related to dissolved oxygen in Narakkal coconut groves and the CIBA experimental pond.
- Oscillatoria spp showed positive relationship with dissolved oxygen in Narakkal coconut groves.
- Abundance of polychaete worms showed a direct relationship to available phosphorus in the soil at the CIBA experimental pond. Polychaete worms also showed a positive relationship with organic matter in Cherai Pokkali fields.
- Copepods have a positive relationship with organic matter at Cherai pokkali fields and in the CIBA supply canal. A similar relationship for copepod with dissolved oxygen and water phosphates in Cherai pokkali fields and Narakkal coconut goves has also been observed.

- The Lab-Lab production is negatively related to rainfall and dissolved oxygen.
- Production of Lab-Lab is dependent upon the prevailing temperature, salinity, pH, free CO_2, Nitrate, and Phosphate and it showed a positive relationship with these parameters.
- Since the Lab-Lab is growing at the pond bottom the texture and nutrient status of the soil is very important. In the present study it has been observed that "Lab-Lab" production is directly related to the level of organic carbon, organic matter, available phosphorus and total nitrogen.

In Cherai Pokkali fields, rainfall and dissolved oxygen showed a negative relationship with total Lab-Lab production ($p < 0.05$) whereas temperature, salinity organic matter, total nitrogen and available phosphorus showed positive relatiobship ($p < 0.05$).

In Narakkal coconut groves, Lab-Lab production is negatively significant to rainfall and positively significant to temperature. Salinity, water phosphate, organic matter, total nitrogen and available phosphorus.

In the CIBA experimental pond, the production of Lab-Lab showed a negative relationship with rainfall ($p < 0.05$) and a positive relationship showed with temperature, salinity, water phosphate, organic matter, total nitrogen and available phosphorus.

In the CIBA supply and canal, rain fall and dissolved oxygen have shown a negative relationship with "Lab-Lab" production at 5% level, whereas temperature, salinity, waterphosphates, organic matter, total nitrogen and available phosphorus showed positive relationship with "Lab-Lab" production at 5% level.

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